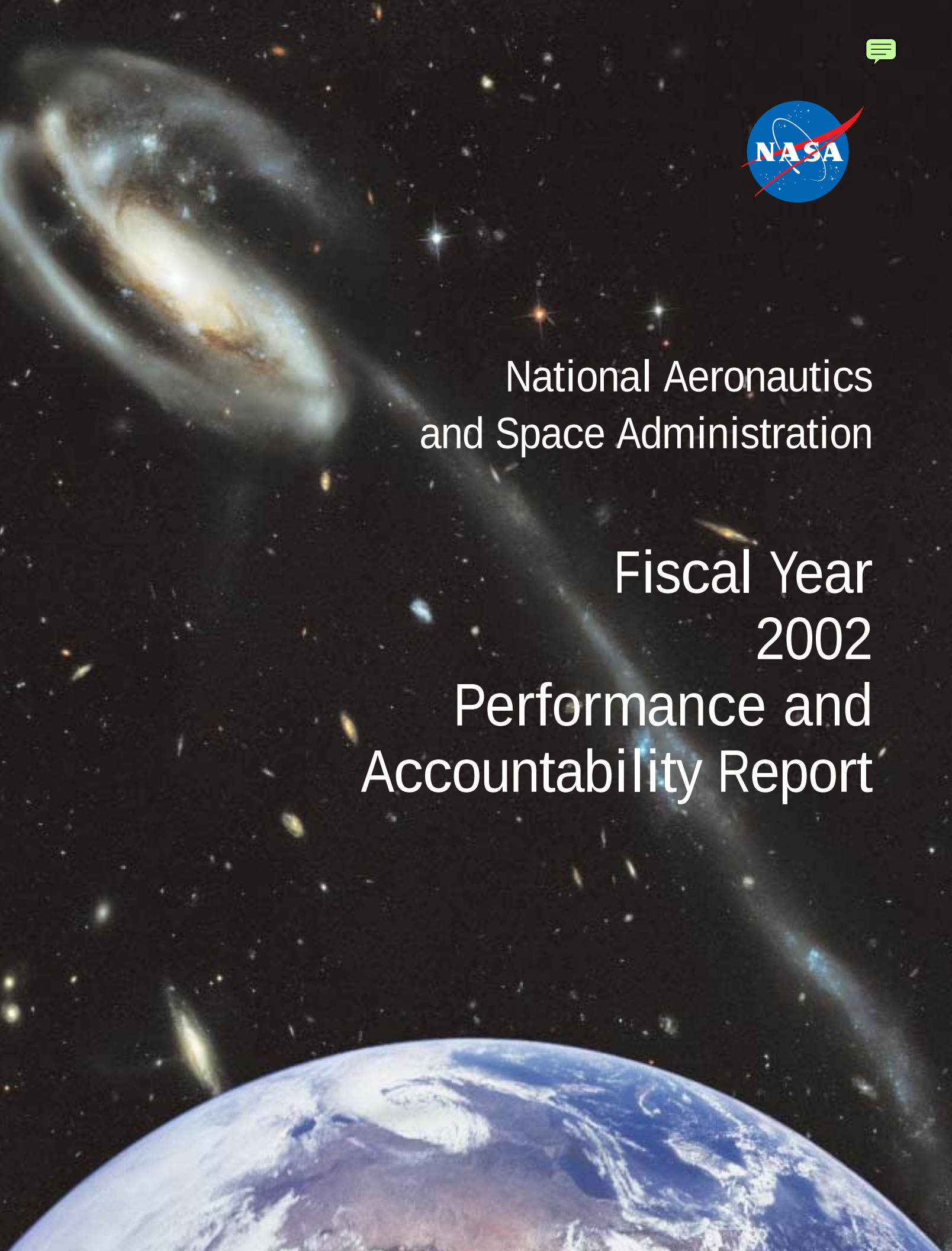

National Aeronautics
and Space Administration

Fiscal Year 2002 Performance and Accountability Report

The NASA Vision

To improve life here,
To extend life to there,
To find life beyond.

The NASA Mission

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.

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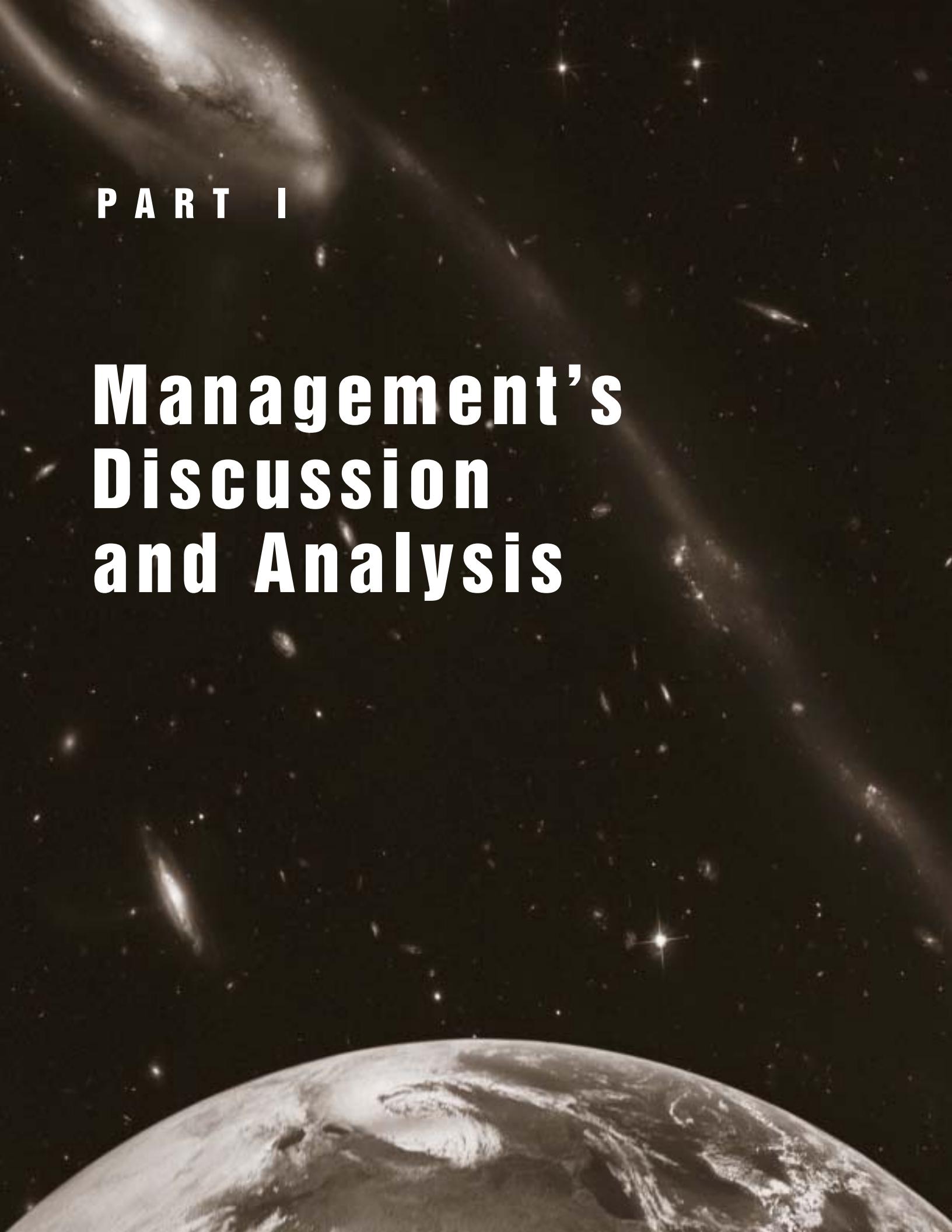
PART I

Management's Discussion and Analysis



Transmittal Letter

Message From the Administrator

I am pleased to present the NASA Fiscal Year 2002 Performance and Accountability Report. Over the past year, we began to implement significant changes that will greatly improve NASA's management, while continuing to break new ground in science and technology. We made excellent progress in implementing the President's Management Agenda. As the Office of Management and Budget reported in its FY 2002 midsession review on progress implementing the President's Management Agenda, "NASA is leading the government in its implementation of the five government-wide initiatives." We received an unqualified audit opinion on our FY 2002 financial statements. We achieved the vast majority of our performance goals, furthering each area of our mission:

To understand and protect our home planet

In FY 2002, we investigated solar flares to help explain and predict damage the Sun causes to communications systems and power grids on Earth. We documented changes to the Earth's ice mass that affect the oceans, ocean ecosystem food chains, and the climate. Our observations from space enhanced efforts to track and predict the spread of West Nile Virus. We advanced technologies that may by the end of this decade double weather forecast accuracy and refine hurricane prediction capabilities. We helped the U.S. Forest Service use our satellite data to determine how best to mobilize scarce firefighting resources. Our aeronautics research continued to make progress in ensuring that air travel is not only safer, but also quieter and cleaner. Our researchers demonstrated a new device that monitors the air for bacterial spores and may help detect biohazards such as anthrax.

To explore the universe and search for life

During FY 2002, our Mars Odyssey spacecraft went into orbit around the Red Planet. At the Martian north and south poles, the spacecraft detected vast amounts of water ice—so much ice that, if thawed, it would fill Lake Michigan twice. This confirmed that our nearest neighbor has abundant supplies of one of the key elements needed for life. We also discovered new planets in other solar systems, including a Jupiter-sized planet that is about as far from its parent star as Jupiter is from our Sun. This suggests that there may be Earth-like planets as well in such systems.

We investigated other space mysteries. For the first time, astronomers tracked the life cycle of x-ray jets from a deep-space black hole. In a fitting culmination to his decades of work in exploring cosmic x-ray sources, NASA-sponsored researcher Riccardo Giacconi won the Nobel Prize in Physics. Investigating other exploration modes, we demonstrated technologies to make planetary rovers more autonomous, able to respond to unexpected events, replan their course, and even improvise science experiments when opportunities arise.

Further enhancing our space science capabilities, the Space Shuttle Columbia (STS-109) completed a spectacular servicing mission to the Hubble Space Telescope. Making one of the best astronomical observatories ever built even better, the crew installed new solar panels, an improved central power unit, and a new camera that increased Hubble's "vision" tenfold. They even revived a disabled infrared camera. Hubble rewarded these efforts with stunning data and images including new measurements of the age of the universe based on observations of the oldest stars.

The Shuttle continued its superb safety record. In addition to the Hubble mission, we flew three other Shuttle missions in FY 2002, delivering crew, supplies, and assembly pieces to the International Space Station. Although we had originally planned for seven flights in FY 2002, we delayed three flights because of propulsion system safety concerns. The vigilant, diligent work that went into discovering and repairing tiny cracks in the propellent lines was just one example of NASA employees constantly making the difference that keeps our operations safe.

FY 2002 was the second year of continuous, permanent human habitation of the International Space Station. As the Station's size and capabilities grew, so did the amount of scientific research it hosts. Astronaut Peggy Whitson came on board as the Station's first Science Officer to coordinate efforts of the Station's international research teams.

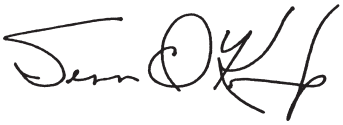
To inspire the next generation of explorers

During FY 2002, we made progress toward creating an Education Enterprise to coordinate all of our education and outreach activities. We also announced that Barbara Morgan will become NASA's first Educator Astronaut, flying on STS-118 next November. NASA's education and outreach work will not only enhance U.S. education and the scientific and technical literacy of our citizens, it will also help build the future workforce our Nation needs to remain a leader in science and technology.

. . . as only NASA can

In FY 2002, we comprehensively changed our structure and management philosophy to reflect the concept of "One NASA," focusing all of NASA's elements on achieving our new Vision and Mission. This is a robust, flexible, research-driven philosophy that maximizes our efficiency in meeting Agency goals. One example of this is the new Integrated Space Transportation Plan. It systematically coordinates all of our space transportation investments to support science-driven exploration and continue safe, reliable access to the Space Station. Similarly, we rigorously assessed Space Station research and adjusted our investments to focus on the highest priority research.

In FY 2003, we will continue assembly of the International Space Station nearing completion of the U.S. core, conducting new research there and on the Shuttle, sending rovers and other exploratory spacecraft to Mars, and launching spacecraft to better monitor the Earth. We are facing a very exciting period of challenges, changes, and expanding scientific accomplishment. I hope that as you read this report, you will share my pride in and enthusiasm for NASA's FY 2002 achievements.



Sean O'Keefe

NASA Administrator

Reliability and Completeness of Financial and Performance Data

The performance data in this report indicate the extent to which NASA achieved the performance measures that we specified in the FY 2002 Revised Final Annual Performance Plan. These performance measures help gauge how well we met our goals. Experience has taught us that measuring performance in a cutting-edge research and development environment is a challenging process. Most of our projects are complex multiyear efforts with inherently unpredictable outcomes and timelines. Therefore, many of our goals are not specific because we work in the realm of discovery and the unknown. Finding measures that are concrete yet clearly linked to goals is often difficult. As we are strongly committed to explaining to the Administration, Congress, and the U.S. public the progress we are making toward our goals, we regularly attempt to improve our performance measures.

The FY 2002 Revised Final Annual Performance Plan and the Performance and Accountability Report reflect such efforts in several program areas. We hope that the new performance measures provide a clearer link between quantifiable results and ambitious long-term goals. In addition, I am pleased to state that for the FY 2004 Performance Plan, which is included in the new Integrated Budget and Performance Document, we have redesigned performance measures Agency-wide to better relate to outcomes. This in-depth effort eclipses the ad hoc work that individual program areas conducted previously to devise better measures. Future reports will benefit from this effort. Outcomes and measures in future performance plans will be refined and made more concise and quantifiable. With regard to completeness and accuracy, the FY 2002 report makes a conscientious effort to provide all pertinent data that are available, to ensure that they are reliable, and to identify the few deficiencies that exist.

The financial data contained in this report are presented fairly, as attested to by the independent public accountant that rendered an unqualified audit opinion on the FY 2002 financial statements.

Sean O'Keefe

NASA Administrator

NASA's decades-long efforts are recognized with the Nobel Prize in Physics

A NASA-funded researcher, Riccardo Giacconi (left) of Johns Hopkins University, was the co-recipient of the 2002 Nobel Prize in Physics "for pioneering contributions to astrophysics, which have led to the discovery of cosmic x-ray sources." Giacconi discovered the first x-ray stars and the x-ray background in the 1960s. In 1976, Giacconi and Harvey Tananbaum of the Harvard-Smithsonian Center for Astrophysics submitted a proposal letter to NASA to initiate the study and design of a large x-ray telescope. In 1977, work began on the program, which was then known as the Advanced X-ray Astrophysics Facility, and in 1998 renamed the Chandra X-ray Observatory. With NASA, he also detected sources of x-rays that most astronomers now consider to contain black holes.

Giacconi said that receiving the award confirms the importance of x-ray astronomy. "I think I'm one of the first to get the Nobel prize for work with NASA, so that's good for NASA and I think it's also good for the field," she said.

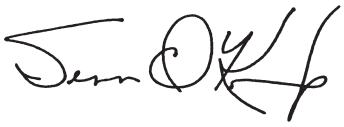
Federal Managers' Financial Integrity Act Statement of Assurance

With reasonable assurance, I certify that NASA complies with the management controls prescribed by the Federal Managers' Financial Integrity Act. However, based on NASA's review of its financial systems, until NASA's Integrated Financial Management Program Core Accounting System is fully implemented during FY 2003, our financial management systems do not substantially comply with Federal financial management system requirements and applicable Federal accounting standards.

In FY 2002, we downgraded the single material weakness we had identified in the FY 2001 Accountability Report to a significant area of management concern that we will monitor internally. This material weakness pertained to International Space Station cost management. To address this issue, I appointed the NASA Deputy Administrator to chair NASA's Internal Control Council and lead it in reforming how we track preventive and corrective actions for management control deficiencies. The Council vigorously monitored the actions we took to address this material weakness. The Integrity Act Material Weaknesses and Non-Conformances section of this report further describes these corrective actions. We will continue to track internal corrective actions, and International Space Station Program and budget officials will continue to report to the Council at regular progress meetings in FY 2003.

In response to discussions held at the November 2002 Internal Control Council and external audit findings, I have chosen to report one material weakness for corrective action in 2002. I have agreed that internal control deficiencies in the reporting and valuation of property, plant, and equipment, and materials meet the criteria for material weakness prescribed by the Federal Managers' Financial Integrity Act. The description of property, plant, and equipment, and materials reporting in this report provides a summary of corrective actions already taken and those scheduled for continuing reviews and corrective action.

With regard to other management issues, a comprehensive discussion of how we are addressing major management challenges is included in the Management Challenges and High-Risk Areas section of this report. Financial systems conformance is described in Part III.



Sean O'Keefe

NASA Administrator

Overview

Mission

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.

Organizational Structure

NASA has revised its organizational structure. This report reflects the previous structure that was in place two years ago when we developed the FY 2002 Revised Final Annual Performance Plan. In addition to describing that structure to provide context for this report's performance information, this discussion briefly notes our new structure. A more detailed description of the new structure is available in the 2003 Strategic Plan and the FY 2004 Integrated Budget and Performance Document.

The structure in place in FY 2002 entails five Enterprises responsible for our activities: Space Science, Earth Science, Biological and Physical Research, Human Exploration and Development of Space, and Aerospace Technology. Space Science manages the Hubble Space Telescope and missions to other planets. Earth Science is responsible for increasing knowledge of Earth as a planetary system. Biological and Physical Research uses the space environment as a laboratory to make discoveries in microgravity conditions. Human Exploration and Development of Space is responsible for the Space Shuttle and the International Space Station, space communications, and expendable launch vehicles. Aerospace Technology achieves advances in the capabilities and safety of civil aviation and improves our access to space. Supporting these Enterprises are four Crosscutting Processes essential to the success of our programs: they are Manage Strategically, Provide Aerospace Products and Capabilities, Generate Knowledge, and Communicate Knowledge. Part II of this report describes these activities.

Institutionally, NASA is composed of Headquarters in Washington, DC, nine Field Centers nationwide, and the Jet Propulsion Laboratory, a federally funded research and development center operated under contract by the California Institute of Technology. The private sector assists with NASA's program activities under contract. NASA also conducts cooperative work with other U.S. agencies and international organizations. Our workforce of public servants and contractors is our greatest strength—a skilled, diverse group of scientists, engineers, managers, and support staff. They are committed to achieving NASA's mission safely, efficiently, and with integrity.

NASA Headquarters and the Centers have distinct, complementary roles. Headquarters sets policy and program direction. It has responsibility for communications with the Administration and Congress, and is the focal point for accountability with external entities. It leads the development of the budget, the strategic and performance plans, and the performance reports. Headquarters consists of the Office of the Administrator, the Enterprises, the Office of Inspector General (OIG), and support offices that coordinate Agency-wide functions. The Office of the Administrator oversees policy implementation, administration, and program management. The Enterprises set specific program direction; they are responsible for NASA's main lines of business. They oversee and coordinate the work of the NASA Centers nationwide (including the Jet Propulsion Laboratory). The Centers are responsible for carrying out most of the program work. Although each has unique strengths, they collaborate as "One NASA."

As part of the new structure that will be evident in subsequent reports, NASA is establishing a sixth Enterprise—Education—devoted to sharing the results of our work and inspiring the next generation of explorers, scientists, and engineers. In addition, this new structure renames Human Exploration and Development of Space as the Space Flight Enterprise. Finally, the new structure replaces the Crosscutting Processes with a different means of accounting.

The new Strategic Plan and the FY 2004 Integrated Planning and Budget Document, both issued along with this report in February 2003, include the new structure and new performance measures. We will work to ensure continuity between this FY 2002 Performance and Accountability Report and performance measures in plans and reports that reflect the new structure. This includes establishing linkages between specific annual performance goals in this FY 2002 Performance and Accountability Report and the new annual performance goals to provide useful trend data.

National Aeronautics and Space Administration

Office of the Administrator

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Frederick D. Gregory, *Deputy Administrator*
Courtney Stadd, *Chief of Staff and White House Liaison*
James L. Jennings, *Associate Deputy Administrator for Institutions and Asset Management*
Michael A. Greenfield, *Associate Deputy Administrator for Technical Programs*
Theron M. Bradley, Jr., *Chief Engineer*
Vacant, *Chief Technologist*
Patrick A. Ciganer, *Program Executive Officer for Integrated Financial Management*
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Aerospace Safety Advisory Panel

NASA Advisory Council

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Human Resources
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Paul G. Pastorek
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Thomas S. Luedtke
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John D. Schumacher
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Management Systems
Jeffrey E. Sutton
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David A. Saleeba
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Space Flight
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Associate Administrator

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- *George C. Marshall Space Flight Center*
  Arthur G. Stephenson
- *John C. Stennis Space Center*
  William W. Parsons, Jr.

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Associate Administrator

Safety and Mission Assurance
Bryan D. O'Connor
Associate Administrator

Aerospace Technology
Jeremiah F. Creedon
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  G. Scott Hubbard
- *Dryden Flight Research Center*
  Kevin L. Petersen
- *Langley Research Center*
  Delma C. Freeman, Jr. (Acting)
- *John H. Glenn Research Center at Lewis Field*
  Donald J. Campbell

Space Science
Edward J. Weiler
Associate Administrator

- *Jet Propulsion Laboratory **
  Charles Elachi

Biological and Physical Research
Mary E. Kicza
Associate Administrator

Earth Science
Ghassem R. Asrar
Associate Administrator

- *Goddard Space Flight Center*
  Alphonso V. Diaz

** Jet Propulsion Laboratory is a contractor-operated facility.*

January 17, 2003

Highlights of Performance Goals and Results

METHODOLOGY

The NASA 2000 Strategic Plan includes strategic goals that NASA must achieve in order to accomplish our mission. Supporting each strategic goal are several strategic objectives. The Performance section (Part II) of this report lists the strategic goals and objectives (from the September 2000 Strategic Plan) upon which our FY 2002 work was based.

NASA undertakes many activities to achieve the strategic goals and objectives included in our Strategic Plan. The steps toward these goals and objectives appear in an annual performance plan. We report our progress in achieving the steps specified in this annual plan by means of an annual performance report. All of these documents—the Strategic Plan, annual performance plan, and performance report—are Congressionally required. This year, the annual performance report is combined with another Congressionally mandated report to constitute the FY 2002 Performance and Accountability Report.

To measure performance, both the annual plan and the annual report use the same basic unit: the annual performance goal. Lower-level measures called indicators help determine whether we have met each annual performance goal. Because much of our work relies on discovery and innovation, many of our performance indicators are activities that have never been performed before or whose chances of success are difficult to estimate. For this reason, we sometimes set annual performance goal achievement equal to the achievement of a certain proportion of indicators. While we may not expect to achieve all of the indicators or even know which of them will bear the most important results, we know that in achieving most of them, we will have made significant progress toward accomplishing our annual performance goal.

To rate our success, we assign a color code shown in the table below. This year, we have added shapes to the color code to make the code accessible to people who have difficulty distinguishing colors and to allow the codes to remain meaningful even in black-and-white. The Supporting Data section in Part II provides charts using these codes to show not only how well we performed on each annual performance goal during FY 2002 but also whether any trends are emerging over time.

For the following summary of results for the Agency as a whole and by Enterprise, we have combined the four rating categories described previously into two. We have combined annual performance goals rated green (achieved) and those rated blue (exceeded) into a single group of positive results; we call this "Achieved or Exceeded" and designate it with the color green. Similarly, we combined red results rated (failed) and yellow (failed but achievement anticipated within the next fiscal year) into a single "Not Achieved" category and designate it with the color red. Also included are performance ratings for fundamental supporting activities called Crosscutting Processes.

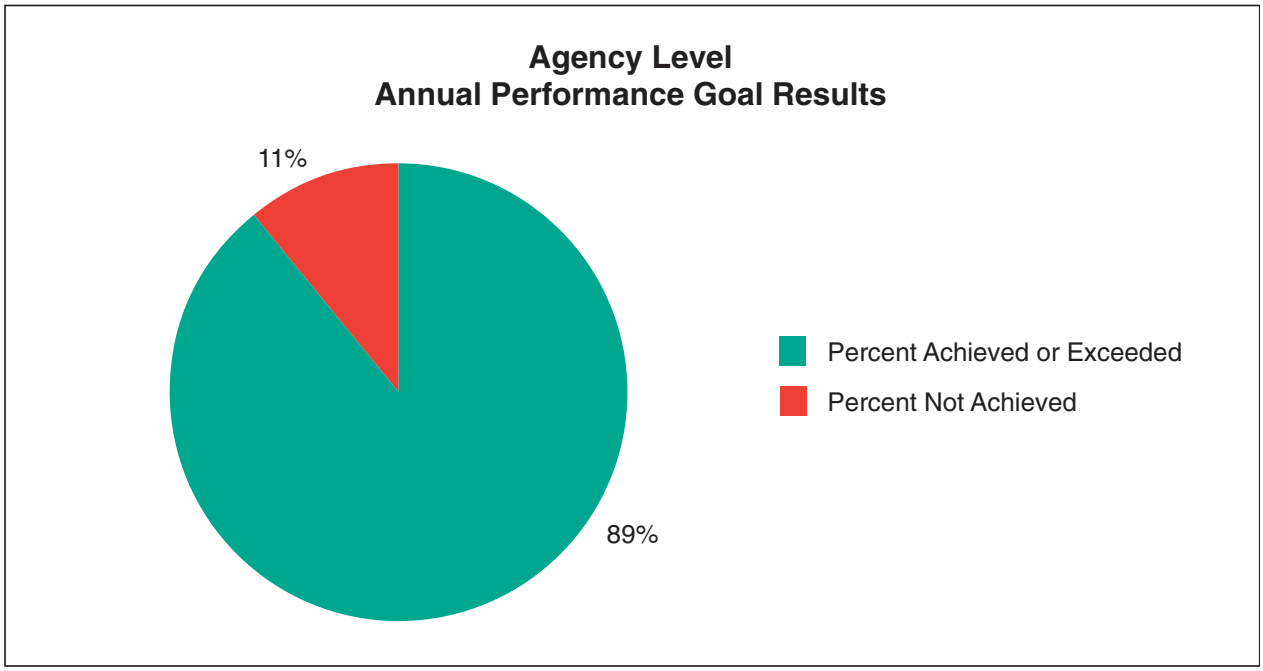
Specific results for all of NASA's annual performance goals and indicators are detailed in the Performance section (Part II). In the Annual Performance Goals Trends charts, annual performance goals for which no activities occurred in previous years are designated with the code "N/A." A blank space indicates an annual performance goal that did not exist in previous years.

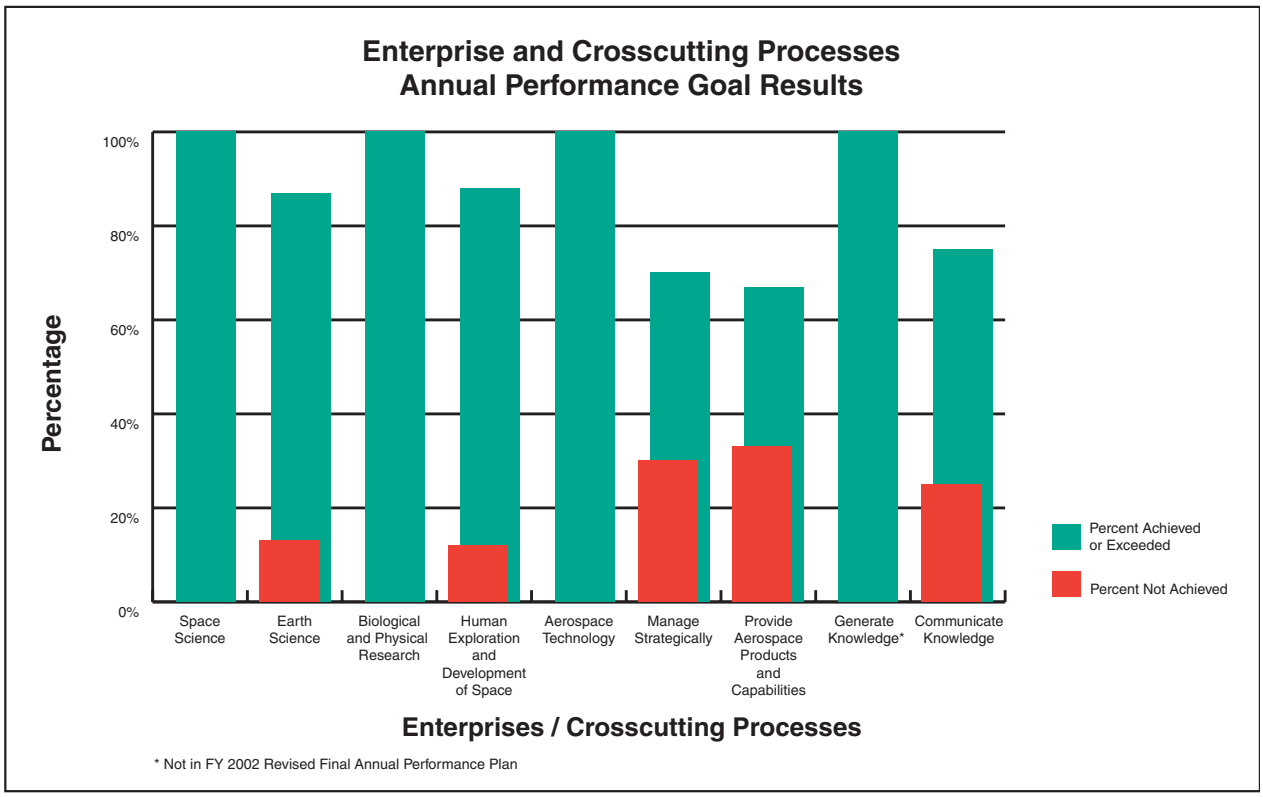
SUMMARY OF RESULTS

As the chart on the following page shows, the Agency achieved excellent results in FY 2002, with 89 percent of our annual performance goals in the "Achieved or Exceeded" category and only 11 percent in the "Not Achieved" category. Our performance marks a distinct upward trend from FY 2001, when we achieved or exceeded 79 percent of the annual performance goals and failed to achieve 21 percent.

Performance Assessment Codes

Code	Definition
◆	Significantly exceeded annual performance goal
●	Achieved annual performance goal
▲	Failed to achieve annual performance goal, progress was significant, and achievement is anticipated within the next fiscal year
■	Failed to achieve annual performance goal, completion within the next fiscal year is not anticipated, and target may be infeasible or unachievable
N/A	No longer applicable





PERFORMANCE HIGHLIGHTS

The following are highlights of NASA's FY 2002 efforts to achieve key goals grouped by Enterprise, strategic goal, strategic objective, annual performance goal, and indicator. Part II of this report contains the rest of NASA's FY 2002 performance data. Crosscutting Processes are included only in Part II.

Space Science

One of NASA's most important functions is to search for life beyond Earth—in terms of our vision, "to find life beyond." This effort has profound consequences: both a fuller understanding of the universe and our place in it and more information on the nature and potential forms of life itself. Another key space science activity is looking far

ahead and far back in space and time to increase human understanding of the universe's beginnings and its ultimate fate. Closer to home and with more immediate effect on our everyday lives is the study of the Sun and how it interacts with Earth. The Sun provides energy and comfort but also poses threats to spacecraft and to power and communications systems. Investigating solar activities and how they affect our planet helps us better understand and avoid these hazards. Major achievements of NASA in FY 2002 advanced all of these lines of effort. Highlights are described below. The remainder of our performance measures and results are in the Performance section (Part II).

Strategic Goal 1. Science: chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life

Strategic Objective 3. Learn how galaxies, stars, and planets form, interact, and evolve

Annual Performance Goal 2S3. Earn external review rating of green, on average, on making progress in the following research focus areas: observe the formation of galaxies and determine the role of gravity in this process; establish how the evolution of a galaxy and the life cycle of stars influence the chemical composition of material available for making stars, planets, and living organisms; observe the formation of planetary systems and characterize their properties; and use the exotic space environments within our solar system as natural science laboratories and cross the outer boundary of the solar system to explore the nearby environment of our galaxy.

The NASA space science effort achieved a rating of green for this annual performance goal. We re-evaluated our approach to our strategic goals and objectives and revised our annual performance measures for 2002. Therefore, a one-to-one match with previous years is not possible.

Indicator 1. Demonstrate significant progress toward the goal, as determined by external expert review

Results. For the focus area "observe the formation of galaxies and determine the role of gravity in this process," we achieved the following:

Observations by the Hubble Space Telescope suggest that the cosmic star formation rate may have been more intense at early cosmic times than was previously suspected, peaking less than 1 billion years after the Big Bang. This result is important for the understanding of the early assemblage of galaxies. The installation of the Advanced Camera for Surveys on Hubble and the revival of its near-infrared camera and multiobject spectrometer with the cryocooler provide a substantial increase in capabilities for such galaxy evolution studies. Unfortunately, the delay in the launch of the Space Infrared Telescope Facility has kept us from getting very important data about older stellar populations. Such observations will both complement and test the Hubble observations of the rate of star formation in these early galaxies.

The Far Ultraviolet Spectroscopic Explorer (FUSE), along with Hubble, has given astronomers their best glimpse yet at the ghostly cobweb of helium gas that underlies the universe's structure. Such observations help confirm theoretical models about how matter in the expanding universe condensed into a web-like structure. This structure, which arose from small gravitational instabilities seeded in the chaos just after the Big Bang, fills even the voids between galaxies and traces the architecture of the universe back to very early times.

Data from the 2-Micron All Sky Survey (2MASS) spacecraft have been used to make what is to date the most accurate determination of the galaxy luminosity function. Because the near-infrared light collected in the 2MASS comes from the oldest, smallest stars, this infrared luminosity function represents the galaxy mass distribution, a fundamental quantity that is a key element in models of structure growth and galaxy evolution.

The Chandra X-ray Observatory has produced an x-ray image of unprecedented resolution of a major galaxy merger that shows two faint x-ray sources near its center. These two x-ray sources could be massive black holes, perhaps destined to merge into an even more massive black hole, with possible consequences for the galaxy's near-term evolution. By tracing the very hot gas in these energetic, dynamic systems, x-ray observations provide a crucial new view of the behavior of galaxies in a major merger, and Chandra observations provide a sensitivity and resolution never before possible. In a related discovery, Hubble observations of ultra-luminous infrared galaxies have shown most to harbor double, multiple, or complex nuclei, highlighting the importance of mergers in the galaxy-building process.

For the focus area "establish how the evolution of a galaxy and the life cycle of stars influence the chemical composition of material available for making stars, planets, and living organisms," we achieved the following:

Hubble provided images of the intricate structure of the interstellar medium and of the influence of star formation, massive stellar winds, and supernovae on galactic-scale chemistry and kinematics. In addition, early-release data suggest that Hubble's new wide-field Advanced Camera for Surveys will certainly meet and likely exceed expectations for image quality and sensitivity.

The 2MASS survey provides an ideal database for studying large-scale interstellar structures within our own galaxy. Its wavelength coverage and depth allow studies of molecular cloud environments with unprecedented detail, from low-density cloud edges to the densest regions where stars are actually being formed. This allows the radial structure of precollapse molecular cores to be determined for several regions.

Observations of the Orion Nebula Cluster by the Chandra X-ray Observatory have revealed the commonality of intense x-ray flux early on in the formation of solar systems. Of particular interest in very young solar-type stars is flare activity 30 to 300 times as intense as the most extreme such events on our own Sun. This suggests a substantially higher proton flux that may explain current meteoric abundance patterns.

Chandra has provided the best, highest resolution x-ray image yet of two Milky Way-like galaxies in the midst of a head-on collision. Since all galaxies—including our own—may have undergone mergers, particularly in their youth, this provides insight into how the universe came to look as it does today. Chandra X-ray Observatory observations show an explosive release of energy from the central regions of the merger, a superwind that appears to be fueled by the birth of hundreds of millions of new stars.

For the focus area "observe the formation of planetary systems and characterize their properties," we achieved the following:

Scientists have analyzed images from Hubble's infrared camera and studied the dust disk structure around the star TW Hydrae to search for planets. A ripple feature is seen in the disk some 85 astronomical units from the parent star, but no planet is seen down to the size of 10 Jupiters at distances beyond 50 astronomical units. Further observations are planned.

The FUSE spacecraft is providing evidence about the lifetime and composition of gas in such disks, which are the sites of planet formation. Results from the disk around the nearby star Beta Pictoris suggest that either there is much less gas left in this 12-million-year-old disk than previously thought, or that dust is distributed very nonuniformly. Observations of the star 51 Ophiuchi suggest that it is a young version of Beta Pictoris and may, at only 300,000 years old, contain planetesimals (small planetary building blocks) with a different chemical composition from our solar system.

Infrared images from the Keck Observatory of a disk around Beta Pictoris reveal an important clue to the configuration of dust confined to a solar-system-sized region close to the star: the dust orbits in a plane that is offset by about 14 degrees from that of the outer disk. Moreover, the offset is in the opposite direction from that of a larger scale warp detected previously by the Hubble. This double warp could be evidence of one or more unseen planets. It is among the strongest evidence yet that disks around stars are where planets form.

For the focus area "use the exotic space environments within our solar system as natural science laboratories and cross the outer boundary of the solar system to explore the nearby environment of our galaxy," we achieved the following:

Scientists made significant advances, both theoretical and observational, in understanding magnetic field reconnection, the basic process responsible for explosive energy releases in solar flares, coronal mass ejections, and Earth's magnetosphere. Although this process is universal and important in the fundamental physics of laboratory plasmas and astrophysics, it is, perhaps, best studied in the Sun's atmosphere and Earth's magnetopause. New observations, enabled in part by the capabilities of NASA instruments on the four-spacecraft European Space Agency Cluster mission, have proven very powerful when combined with our current theoretical understanding. These new data indicate that some of the characteristics (geometry, scale, and electromagnetic fields) of reconnection events seen in space are consistent with those expected from theory and simulations. On the other hand, some parameters, such as the electric field tangent to the magnetopause, appear to be at least an order of magnitude smaller than suggested by some simulations. This result is important because the rate of electromagnetic energy conversion is proportional to the magnitude of this tangential electric field. These observations are driving rapid progress in understanding the reconnection process.

Observations made by the Ulysses, Voyager, and Wind spacecraft are providing new information on the physical and chemical characteristics of the interstellar medium. Ulysses measurements of interstellar pickup ions and Voyager observations of solar wind slowing are now giving a reliable measure of the local density of neutral interstellar hydrogen. Voyager and Wind observations of anomalous cosmic ray sodium, magnesium, silicon, and sulfur significantly exceed what is expected from an interstellar neutral source, suggesting the presence of other extended sources of pickup ions in the outer heliosphere, such as Kuiper Belt objects. The Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) spacecraft has made the first observations of the neutral component of the solar wind. These observations, along with Ulysses measurements, permit us to assess the mechanisms by which interplanetary dust creates the neutral solar wind and estimate the amount and size distribution of dust in the inner solar system.

Data Quality. Mission data accurately reflect performance and achievements in FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA's Space Science Advisory Committee delivers its findings directly to NASA management. Minutes of their meetings are located at http://spacescience.nasa.gov/adv/sscacpast.htm.

Performance outcomes are reported through normal mission reviews and are verified and validated by the program executive or program scientist. For descriptions of all space science missions that support this objective and example data, see http://spacescience.nasa.gov/missions/.

Indicator 2. Obtain expected scientific data from 80 percent of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year)

The operating missions that support this goal are the Microwave Anisotropy Probe, the FUSE, the Submillimeter Wave Astronomy Satellite (SWAS), and Hubble. Each mission achieved its data collection and operation efficiency levels. Each mission obtained expected scientific data in FY 2002, operating with very few unplanned interruptions. The FUSE spacecraft experienced a serious problem with its pointing system in December 2001. The problem interrupted science operations for 7 weeks until a heroic engineering effort successfully restored the mission to productivity.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are retrieved from normal project management reporting and are verified and validated by the program executive or program scientist. For descriptions of the space science missions that support this objective, see http://spacescience.nasa.gov/missions/.

Strategic Objective 6. Probe the evolution of life on Earth, and determine if life exists elsewhere in our solar system

Annual Performance Goal 2S6. Earn external review rating of green, on average, on making progress in the following research focus areas: Investigate the origin and early evolution of life on Earth, and explore the limits of life in terrestrial environments that might provide analogues for conditions on other worlds; determine the general principles governing the organization of matter into living systems and the conditions required for the emergence and maintenance of life; chart the distribution of life-sustaining environments within our solar system, and search for evidence of past and present life; and identify plausible signatures of life on other worlds.

The NASA space science effort achieved a rating of green for this annual performance goal. We re-evaluated our approach to our strategic goals and objectives and revised our annual performance measures for 2002. Therefore, a one-to-one match with previous years is not possible.

Indicator 1. Demonstrate significant progress toward the goal, as determined by external expert review

Results. For the focus area "investigate the origin and early evolution of life on Earth, and explore the limits of life in terrestrial environments that might provide analogues for conditions on other worlds," we achieved the following:

The NASA Research and Analysis Program supported studies that led to major advances in knowledge about the limits of life on Earth. These include the surprisingly high eukaryotic-cell (cells with a nucleus) biodiversity in a very acid environment, the Rio Tinto, Spain, and the active microbes at extreme pressures. The Rio Tinto is very acidic (pH 2) and contains high concentrations of heavy metals, an environment where scientists expected eukaryotic cells to be scarce. However, more than half of the cells were eukaryotic, and several new eukaryotic lineages were found. Furthermore, the fact that some microbes are viable at extreme pressures, well above 1,000 times the Earth's atmospheric pressure at sea level, expands by an order of magnitude the range of habitable zone conditions that we think may exist in the solar system.

For the focus area "determine the general principles governing the organization of matter into living systems and the conditions required for the emergence and maintenance of life," we achieved the following:

For the first time, irradiation of ices deposited under interstellar conditions has demonstrated the synthesis of molecules capable of self-assembly, forming protocells. Several recent laboratory studies have also reinforced the feasibility of the single-stranded biomolecule RNA (ribonucleic acid) to function both as a catalyst and as an information molecule—reinforcing the concept of an RNA world preceding our current biological machinery of DNA (deoxynucleic acid) and proteins. In a related discovery, very similar protocells were found in the Tagish Lake meteorite.

In another research area, scientists found that proteins are capable of self-replication and have chiral-selective behavior (that is, left-handed proteins replicating preferentially). It has been a longstanding mystery that all life on Earth uses only left-handed proteins and right-handed sugars, although both chiralities have equal probability. This is the first experimental evidence of a system of proteins preferentially selecting a single chirality.

For the focus area "chart the distribution of life-sustaining environments within our solar system, and search for evidence of past and present life," we achieved the following result:

The Mars Global Surveyor continued to find intriguing features such as gully systems that suggest the presence of water in the recent past. The Mars Odyssey spacecraft began its mapping orbit in February 2002 and already has found saturated water ice at latitudes higher than 60 degrees, matching predictions about where near-surface ice is expected to be stable. Evidence for the presence of near-surface water from measurements by the Odyssey neutron and gamma-ray experiments suggest that life-sustaining environments may have been present on Mars in the past (or may still be present).

For the focus area "identify plausible signatures of life on other worlds," we achieved the following:

There has been significant progress in understanding the potential contribution of microorganisms to Earth's early

biosphere. This understanding is a necessary precursor to developing a catalogue of recognizable global biosignatures to advance the astronomical search for signs of life in other planetary systems. For example, microbial mats release hydrogen or methane into the atmosphere. This increases the loss of hydrogen to space, thereby contributing to the oxidation of our atmosphere.

Recent investigations in the biogenicity of some features in the Martian meteorite ALH84001 and in the purported microfossils formed on Earth 3.5 billion years ago have challenged our concepts of what constitutes a biomarker. The controversy revolves around how reliably we can recognize biogenic magnetite, the potential fractionation of carbon through abiotic processes, and the potential of alternate isotopes such as iron to also serve as biomarkers.

A controversy over whether these ancient rocks contain fossils that indicate life has the potential to change our paradigm of the origin of life on Earth. The current paradigm is that the rapid appearance of life on Earth once it became possible, as reflected in the geological record of Earth's earliest history, indicates that the origin of life is a very likely event and that life could be expected to arise as quickly on other planets that have similar conditions. If the controversy were resolved against the features being fossils of life, then this powerful argument for the early and easy development of life would disappear.

Data Quality. The mission data and science outcomes accurately reflect performance and achievements in FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.

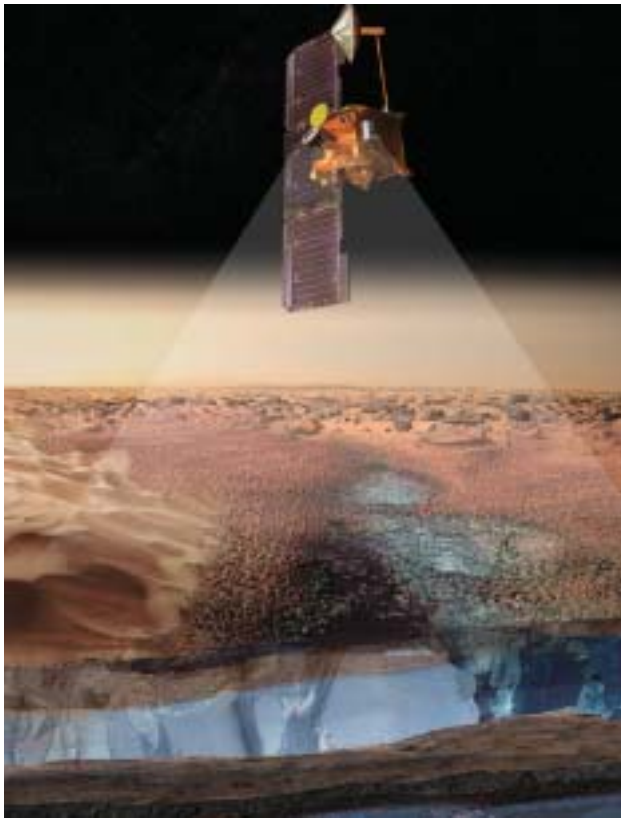
Data Sources. NASA's Space Science Advisory Committee delivers its findings directly to NASA management. Minutes of their meetings are located at http://spacescience.nasa.gov/adv/sscacpast.htm.

Performance outcomes are reported through normal mission reviews and are verified and validated by the program executive or program scientist. For descriptions of all space science missions that support this objective and example data, see http://spacescience.nasa.gov/missions/.

Indicator 2. Obtain expected scientific data from 80 percent of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year)

Results. The operating missions supporting this goal are Mars Global Surveyor and Mars Odyssey. Each mission obtained all expected scientific data during FY 2002, operating normally with very few unplanned interruptions.

Data Quality. The mission data and science outcomes accurately reflect performance and achievements in FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.



NASA finds convincing evidence of ice on Mars

This artist's rendering portrays instruments aboard NASA's Mars Odyssey spacecraft detecting ice-rich layers in the soil of Mars. Measurements by the gamma ray spectrometer instruments indicate that the upper 3 feet of soil contain an ice-rich zone with an ice abundance of 20 to 50 percent by mass. These ice-rich areas surround both the north and south polar regions of Mars down to latitudes of about 60 degrees. The instruments detect the signature of hydrogen, indicating water ice, to a depth of about 3 feet. Scientists do not know whether or how deep the ice-rich zone continues below that depth. The view of the spacecraft in this artist's rendering is not to scale, as the observations are obtained from an orbital altitude of 250 miles.

Data Sources. Performance assessment data are obtained from normal project management reporting and are verified and validated by the program executive or program scientist. For descriptions of the space science missions that support this objective, see http://spacescience.nasa.gov/missions/.

Strategic Objective 7. Understand our changing Sun and its effects throughout the solar system

Annual Performance Goal 2S7. Earn external review rating of green, on average, on making progress in the following research focus areas: Understand the origins of long- and short-term solar variability; understand the effects of solar variability on the solar atmosphere and heliosphere; and understand the space environment of Earth and other planets.

The NASA space science effort achieved a rating of green for this annual performance goal. We re-evaluated our approach to our strategic goals and objectives and revised

our annual performance measures for 2002. Therefore, a one-to-one match with previous years is not possible.

Indicator 1. Demonstrate significant progress toward the goal, as determined by external expert review

Results. For the focus area "understand the origins of long- and short-term solar variability," we achieved the following:

Solar physicists have resolved the longstanding question of what holds sunspots together against disruptive magnetic and turbulent forces. Solar and Heliospheric Observatory (SOHO) scientists measured the intense winds beneath active regions on the Sun and found, below the surface, a planet-size region of in-rushing plasma that clamps a sunspot's magnetic field in place. The strong magnetic field cools the solar atmosphere and the cooler material sinks. The sinking material both deflects the hot rising plumes of gas from below and pulls in gas from the surrounding area, driving winds at speeds of up to 5,000 kilometers per hour. They also found that the cool dark part of a sunspot is much shallower than previously thought. Sunspots and active regions are the source of most solar disturbances that affect Earth and most variable solar radiance. The SOHO mission is a joint activity of the European Space Agency and NASA.

NASA's newest solar telescope, the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI), has been observing solar x-rays and gamma rays in the solar atmosphere since February 2002. Unexpected events occurred on April 21 when RHESSI detected a strong flare brightening in the higher energy gamma rays and x-rays well before another NASA satellite, the Transition Region and Coronal Explorer (TRACE), detected ultraviolet light from the same flare. Scientists believe that the emission associated with hotter material was created before the ultraviolet emission that is associated with lower temperatures. This implies a downward cascade of energy rather than a heating that raises temperature over time in these largest explosions in the solar system.

SOHO mission researchers have found other, gentler wind patterns, more like terrestrial trade winds, 12,000 kilometers below the solar surface. One of the steadiest patterns flows from the equator toward the poles at about 60 kilometers per hour. However, after analyzing data from 1996 to 2002, they found that this pattern unexpectedly reversed direction at high latitudes of the northern hemisphere in 1998. This phenomenon may be related to the asymmetry observed in solar activity between the hemispheres in most 11-year sunspot cycles and suggests effects of the new solar cycle organizing itself below the visible surface of the Sun.

For the focus area "understand the effects of solar variability on the solar atmosphere and heliosphere," we achieved the following:

Puzzling and persistent asymmetries between the Sun's north and south polar regions have been recorded for some time by ground-based observatories. Then, during the last solar minimum, we found a clear north-south asymmetry in the galactic cosmic ray intensity measured by the Ulysses spacecraft and in the 1-astronomical-unit heliospheric magnetic field recorded by the Wind spacecraft. We have inferred that this same north-south asymmetry occurs in the solar open magnetic field strength at several solar radii. Based on Ulysses's solar wind composition measurements, all these observations point to a stronger open magnetic field in the southern solar hemisphere than in the northern hemisphere. Finding the causes and origin of this north-south asymmetry will be an important step in our understanding of fundamental processes on the Sun.

A very large coronal mass ejection and its associated flare on July 14, 2000, produced effects throughout the solar atmosphere and heliosphere. Analysis of these data during FY 2002 provided a new understanding of the effects of rapid solar variations.

For the focus area "understand the space environment of Earth and other planets," we achieved the following:

New observations of the plasmas surrounding Earth using the IMAGE spacecraft have revealed much stronger connections between the ionosphere and magnetosphere than expected. The energy transport from the solar wind through the magnetosphere to the ionosphere is immediate. The ionosphere reacts by ejecting ions up the magnetic field lines into the magnetosphere creating a ring current that, at times, encircles the Earth. As these ions reenter the atmosphere, they further perturb the ionosphere, changing the configuration of the plasma environment around the Earth.

The Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED) spacecraft provided data of exceptional quality on the region where space and the atmosphere meet—until now a missing link in our understanding of the chain of processes that connect the Sun and the Earth. We are now able to observe the completion of the flow of energy, which starts at the center of the Sun and is finally deposited in the Earth's atmosphere. One example of the resulting new science is a study in which scientists used the synergy between two spacecraft (RHESSI and TRACE) to determine the direction of solar flare energy cascade. At the other end of the chain, combining of spacecraft data from IMAGE and TIMED with ground-based instrument data has shown a strong correlation between the amount of structure in the aurora and the amount of energy deposited in the atmosphere.

Data Quality. The mission data and science outcomes accurately reflect performance and achievements in FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA's Space Science Advisory Committee delivers its findings directly to NASA management. Minutes of their meetings are located at http://spacescience.nasa.gov/adv/sscacpast.htm.

Performance outcomes are reported through normal mission reviews and are verified and validated by the program executive or program scientist. For descriptions of all space science missions that support this objective and example data, see http://spacescience.nasa.gov/missions/.

Indicator 2. Obtain expected scientific data from 80 percent of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year)

Results. Supporting missions are SOHO; TRACE; RHESSI; Ulysses; Voyager; the Advanced Composition Explorer (ACE); the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX); Polar; Fast Auroral Snapshot Explorer (FAST); IMAGE; and TIMED. Each mission obtained all expected scientific data in FY 2002, operating normally with very few unplanned interruptions.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are collected through normal project management reporting and are verified and validated by the program executive or program scientist. For descriptions of the space science missions that support this objective, see http://spacescience.nasa.gov/missions/.

Strategic Objective 8. Chart our destiny in the solar system

Annual Performance Goal 2S8. Earn external review rating of green, on average, on making progress in the following research focus areas: understand forces and processes, such as impacts, that affect habitability of Earth; develop the capability to predict space weather; and find extraterrestrial resources and assess the suitability of solar system locales for future human exploration.

The NASA space science effort achieved a rating of blue for this annual performance goal. We re-evaluated our approach to our strategic goals and objectives and revised our annual performance measures for 2002. Therefore, a one-to-one match with previous years is not possible.

Indicator 1. Demonstrate significant progress toward the goal, as determined by external expert review

Results. For the focus area "understand forces and processes, such as impacts, that affect habitability of Earth," we achieved the following:

Between October 1, 2001, and July 1, 2002, scientists discovered and catalogued 78 near-Earth objects with diameters greater than 1 kilometer. Almost all of these discoveries were made through search efforts supported by the Near-Earth Object Observations Program. The total estimated population is about 1,000 to 1,100 objects, of which more than 600 have been discovered and catalogued. NASA is on schedule to catalog 90 percent of near-Earth objects greater than 1 kilometer in diameter by 2008.

For the focus area "develop the capability to predict space weather," we achieved the following:

Measurements by the SAMPEX satellite show that, during large solar-particle events, the geomagnetic cutoff for entry of energetic particles into the magnetosphere is often highly variable. These changes correlate well with changes in geomagnetic activity. The SAMPEX satellite shows that the actual cutoffs generally fall below calculated values and that the Earth's polar cap is larger than expected. During large solar-particle events, the radiation dose on satellites such as the Station will be several times greater than previously expected.

The global ultraviolet imager on the TIMED spacecraft obtained images of equatorial plasma depletions. The images enable surveys of the extent and the distribution of large-scale plasma depletions. The depleted plasma structures are important because they significantly perturb, and even completely disrupt, electromagnetic signal propagation. In addition to causing abrupt communication outages, this phenomenon can also significantly affect global-positioning-system (GPS)-based navigation systems.

The Living With a Star Targeted Research and Technology Program supports a wide-ranging set of theoretical and empirical modeling designed to provide the framework for predicting space weather. Noteworthy studies include applying new methodologies for calculating and forecasting satellite drag; modeling the effects of solar energetic particles and galactic cosmic rays on cloud condensation in the stratosphere; characterizing the plasma environment responsible for spacecraft charging; identifying conditions in the solar wind and magnetosphere that are responsible for the strong variability in the relativistic electron flux in Earth's magnetosphere; and developing new models and software tools for evaluating near-real-time geomagnetic cutoffs.

For the focus area "find extraterrestrial resources and assess the suitability of solar system locales for future human exploration," we achieved the following result:

Mars Odyssey observations indicate the presence of water near the surface of Mars, a potential resource for future explorers. Both Odyssey and the Mars Global Surveyor have identified potentially suitable sites for in-depth surface exploration, a necessary step for possible future human exploration.

Data Quality. The mission data and science outcomes accurately reflect performance and achievements in

FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA's Space Science Advisory Committee delivers its findings directly to NASA management. Minutes of their meetings are located at http://spacescience.nasa.gov/adv/sscacpast.htm.

Performance outcomes are reported through normal mission reviews and are verified and validated by the program executive or program scientist. For descriptions of all space science missions that support this objective and example data, see http://spacescience.nasa.gov/missions/.

Indicator 2. Obtain expected scientific data from 80 percent of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year)

Results. There were no space-based operating missions substantially dedicated to supporting this goal in FY 2002. However, some operating missions have contributed to research in this area (see indicator 1). Future space missions are expected.

Strategic Objective 9. Support of Strategic Plan science objectives; development/near-term future investments (Supports all objectives under the Science goal)

Annual Performance Goal 2S9. Earn external review rating of green on making progress in the following area: design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives.

The NASA space science effort achieved a rating of green for this annual performance goal. We re-evaluated our approach to our strategic goals and objectives and revised our annual performance measures for 2002. Therefore, a one-to-one match with previous years is not possible.

Indicator 1. Meet no fewer than 75 percent of the development performance objectives for major programs/projects, supported by completion of performance objectives in majority of other projects

Major programs/projects:

- *Hubble Space Telescope Development: Begin system test of the Cosmic Origins Spectrograph*
- *Hubble Space Telescope Development: Advanced Camera for Surveys and Solar Array 3 will be ready for flight and installation on Servicing Mission 3B*
- *Space Infrared Telescope Facility Development: Complete integration and test of spacecraft and payload*
- *Stratospheric Observatory for Infrared Astronomy Development: Complete installation of the forward pressure bulkhead*
- *Gravity Probe-B Development: Initiate flight vehicle integration and test*
- *Mars Exploration Rover 2003 Development: Initiate assembly, test, and launch operations process*
- *Mars Reconnaissance Orbiter 2005 Development: Select payload and initiate development*
- *Solar Terrestrial Relations Observatory Development: Have contracts in place for start of spacecraft and instrument detailed design and fabrication*

Other projects:

- *Swift Gamma Ray Burst Explorer Development: Complete build-up of spacecraft subsystems*
- *Full-sky Astrometric Mapping Explorer (FAME) Development: Conduct Confirmation Review*
- *Galaxy Evolution Explorer (GALEX) Development: Complete environmental testing*
- *Comet Nucleus Tour (CONTOUR) Development: Complete environmental testing*
- *Mercury Surface, Space Environment, Geochemistry and Ranging Mission Development: Conduct Critical Design Review*
- *Solar-B Development: Conduct the Pre-Environmental Review for the U.S.-provided Extreme Ultraviolet Imaging Spectrometer*
- *Planck Development: Complete the High-Frequency Instrument flight detectors*

Results. For the 15 development programs and projects, 12 milestones were successfully completed. GALEX development did not complete its environmental testing, and Planck development did not complete the High-Frequency Instrument flight detectors. We determined before its scheduled confirmation review that the FAME mission should be terminated; therefore, we did not hold the review. Highlights of FY 2002 performance follow:

During the March Hubble Space Telescope Servicing Mission 3B, astronauts installed Advanced Camera for Surveys and Solar Array 3. The camera has increased Hubble's optical capacity tenfold, producing breathtakingly clear and detailed images. Already, the revitalized Hubble has allowed astronomers to peer more deeply into the universe, initiating a flurry of discoveries.

The Solar Terrestrial Relations Observatory Development mission has contracts in place for spacecraft and instrument detailed design, and activities are proceeding toward critical design review. This mission will obtain simultaneous (stereo) images of the Sun, using two spacecraft with identical instruments to study coronal mass ejections as they travel toward Earth.

The Mars Exploration Rover mission completed critical design phase and started assembly, test, and launch operations in March 2002. Twenty-eight new scientists participated in the field integrated design and operations test—a field test to maneuver the rover.

The Mars Reconnaissance Orbiter mission selected instruments for the mission early in the fiscal year. The preliminary design review and nonadvocate review were also completed successfully, and the mission received formal approval to proceed to implementation phase.

The CONTOUR spacecraft achieved its FY 2002 metric; however, it suffered an in-space anomaly, and there has been no contact since. The FAME mission, as stated above, was terminated. During spacecraft thermal vacuum testing for GALEX, the attitude and power electronics software failed, which caused the environmental testing to slip. The Planck mission experienced problems in fabricating the bolometers, and we transferred the fabrication of the detector blocks to the Jet Propulsion Laboratory.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are retrieved from normal project management reporting and are verified and validated by the program executive or program scientist. For descriptions of the space science missions that support this objective, see http://spacescience.nasa.gov/missions/.

Strategies and Resources to Achieve Goals

NASA's space science effort works closely with the larger scientific community to articulate science goals that directly support the Agency's scientific research mission. We also establish goals for flight programs, technology development, and education and public outreach. These goals are the framework for formulating and managing the space science program. The space science goals to key activities table shows the relationships among strategic goals, strategic objectives, and key activities.

Mapping Goals and Objectives to Key Space Science Activities

Strategic Goal	Strategic Objective	Key Activity
Science: chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life	Understand the structure of the universe, from its earliest beginnings to its ultimate fate	Operating Missions, Supporting Research and Technology
	Explore the ultimate limits of gravity and energy in the universe	Operating Missions, Supporting Research and Technology
	Learn how galaxies, stars, and planets form, interact, and evolve	Operating Missions, Supporting Research and Technology
	Look for signs of life in other planetary systems	Operating Missions, Supporting Research and Technology
	Understand the formation and evolution of the solar system and the Earth within it	Operating Missions, Supporting Research and Technology
	Probe the evolution of life on Earth, and determine if life exists elsewhere in our solar system	Operating Missions, Supporting Research and Technology
	Understand our changing Sun and its effects throughout the solar system	Operating Missions, Supporting Research and Technology
	Chart our destiny in the solar system	Operating Missions, Supporting Research and Technology
	Support of Strategic Plan science objectives; development/near-term future investments (Supports all objectives under the Science goal)	Space Infrared Telescope Facility, Hubble Space Telescope Development, Gravity Probe B, Stratospheric Observatory for Infrared Astronomy, Solar-Terrestrial Relations Observatory, Gamma Ray Large Area Telescope, Payloads, Explorers, Discovery and Mars Surveyor
Technology/Long-Term Future Investments: develop new technologies to enable innovative and less expensive research and flight missions	Acquire new technical approaches and capabilities. Validate new technologies in space. Apply and transfer technology	Supporting Research and Technology
Education and Public Outreach: share the excitement and knowledge generated by scientific discovery and improve science education	Share the excitement of space science discoveries with the public. Enhance the quality of science, mathematics, and technology education, particularly at the pre-college level. Help create our 21st century scientific and technical workforce	Space Infrared Telescope Facility, Hubble Space Telescope Development, Gravity Probe B, Stratospheric Observatory for Infrared Astronomy, Solar-Terrestrial Relations Observatory, Gamma Ray Large Area Telescope, Payloads, Explorers, Discovery, Mars Surveyor, Operating, Missions, and Supporting Research and Technology

The space science resource estimates table gives budget authority figures for FY 1999 to FY 2002. Funding for the first nine programs supports mission development (for example, pre-launch funding). Funds for our operating missions are combined into one line, as post-launch operations are much less resource-intensive than development. Supporting Research and Technology includes scientific research activities (for example, data analysis, theory, and modeling), as well as early technology development and studies for missions that are not yet ready to proceed into development.

Cost-Performance Relationship

In achieving the strategic goals shown in the mapping space science goals to key activities table, during FY 2002, NASA incurred research and development expenses for the programs as follows. Essentially 100 percent of resources went to research and development, and of this total about 35 percent was spent on basic research and 65 percent on development. No resources were expended on applied research. For a description of the three research categories and a summary of NASA's total research and development expenses, see the "Required Supplementary Stewardship Information—Stewardship Investments: Research and Development" schedule in Part III.

Budget-Performance Relationship

About 84 percent of the FY 2002 space science budget supported the achievement of strategic goal 1, the space science effort's science goal. We made progress toward achieving the first eight strategic objectives associated with this goal through operation of more than 25 scientific spacecraft and the scientific analysis of data returned from those and previous missions ($522 million); basic research, including theoretical and laboratory studies, and the development of new scientific instruments ($253 million); and the launch of scientific payloads on suborbital rockets and high-flying balloons ($42 million). Progress toward objective 9 was made by developing missions that will extend our knowledge in the future ($1.295 billion).

Results in a single year for any particular project (for example, Hubble) rely on investments made over many years, and are usually only a fraction of the total invested in all years on that project.

We spent about 16 percent of the FY 2002 space science budget on achieving strategic goal 2, our space science technology goal. Progress resulted from investments in new technologies and beginning to design future missions. The New Millennium Program ($42 million) focuses on flight-testing (in space) brand-new technologies that we can then use with confidence in future science missions. Our other technology programs ($356 million) invest in early design activities for future missions and overcoming technology challenges to enable those mission designs to work.

The NASA space science education and public outreach program is cost-effective and highly leveraged. Each space science mission or research program directs 1 to 2 percent of its budget toward these activities. This is highly consistent with the Space Act's requirement that NASA broadly

Resource Estimates of Key Space Science Activities

Key Activity	Budget Authority (in $ Millions)			
	FY 1999	FY 2000	FY 2001	FY 2002*
Space Infrared Telescope Facility	120	123	118	132
Hubble Space Telescope Development	160	184	180	170
Gravity Probe B	61	50	41	54
Stratospheric Observatory for Infrared Astronomy	58	42	43	38
Solar-Terrestrial Relations Observatory	0	0	0	59
Payloads	29	15	40	50
Explorers	205	123	141	123
Discovery	124	150	213	217
Mars Surveyor	228	249	430	428
Operating Missions	117	79	123	175
Supporting Research and Technology	916	1,148	966	1,039
Institutional Support/Other	101	31	26	417
Total	**2,119**	**2,194**	**2,321**	**2,902**

*Beginning in FY 2002, Institutional Support is included in each Enterprise. FY 2002 reflects September Operating Plan.

disseminate its results. Beyond this, the program has a modest investment in infrastructure, a small pool of funds for individual investigator grants, and support for a few special projects.

We are fortunate in obtaining substantial additional support from external partners. For example, major museum exhibits often result from NASA contributions of content, technical expertise, and modest funding in partnership with a host museum, other agencies, and/or private donors who provide the design, fabrication, and major funding. The program philosophy is for NASA to provide technical content derived from space science missions and our scientific expertise while external partners provide the major funding, development, and educational expertise.

Earth Science

In FY 2002, we demonstrated our commitment and ability to improve life here on Earth. Detecting and understanding large-scale changes on Earth, using advanced satellite data to better manage water resources and mitigate flood damage, and assisting firefighters to more quickly mobilize resources to combat wildfires are just a few examples of how our FY 2002 Earth science work helped us understand and protect our home planet. Highlights of these activities are described below. The remainder of our goals, objectives, and achievements are discussed in Part II.

Strategic Goal 1. Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth

Strategic Objective 1. Discern and describe how the Earth is changing

Annual Performance Goal 2Y5. Increase understanding of change occurring in the mass of the Earth's ice cover by meeting at least three of four performance indicators.

NASA achieved the annual performance goal with a rating of green. We made progress in understanding mass changes of the Greenland and Antarctic ice sheets. We compiled 20 years of accumulation and melt rates from satellite and field measurements. Mapping Antarctica revealed changes in the margins and ice streams and identified growth and wastage areas.

In addition, NASA improved our ability to separate gravity and elevation change signals when determining the growth or shrinkage of the Earth's ice sheets. This advance will assist in our upcoming Ice, Cloud, and Land Elevation Satellite (ICESat) mission.

Indicator 1. Submit for publication the first Greenland ice sheet accumulation rate and its inter-annual variability maps for the period 1975-98

Results. A peer-reviewed journal published the accumulation rate and its associated maps in December 2001.

Data Quality. Peer-reviewed publication is the most relied-upon assessment of the validity of a scientific accomplishment.

Data Sources. The December 2001 issue of the Journal of Geophysical Research published the map (Bales et al.).

Indicator 2. Provide the first record of changes and variability in extent of Greenland ice sheet surface melt over the 21 years, 1979-1999, and submit for publication

Results. NASA sponsored the analyses, which showed that the Greenland ice sheet melt rate increased from 1979 to 1999 and was accompanied by warmer temperatures. This increased rate occurred on the western side of the ice sheet. A journal published the paper.

Data Quality. Peer-reviewed publication is the most relied-upon assessment of the validity of a scientific accomplishment.

Data Sources. The paper (Abdalati and Steffen) appeared in the December 27, 2001, issue of the Journal of Geophysical Research—Atmospheres.

Indicator 3. Produce the first map of Antarctic ice sheet margin change, 1997-2000, covering key regions of the Antarctic coastline and submit this for publication

Results. We produced the first map of the Antarctic ice margin change by comparing the results from the RADARSAT Antarctic Mapping Mission (RAMM) in 1997 with the Modified Antarctic Mapping Mission in 2000. Some areas showed expanding ice, while others experienced little or no change; still others, such as the Larsen ice shelf, experienced dramatic reductions in ice cover.

Data Quality. Peer-reviewed publication is the most relied-upon assessment of the validity of a scientific accomplishment.

Data Sources. A paper (Jezek et al.) published in Annals of Glaciology in August 2002 compared changes in ice sheet margin. National Geographic also highlighted margin changes in a map in their supplement to the February 2002 issue.

Indicator 4. Define parameters for separating post-glacial rebound from ice mass changes based on Gravity Recovery And Climate Experiment (GRACE) and ICESat observations

Results. We analyzed the parameters needed for separating post-glacial rebound from elevation data even before launching ICESat by using a theoretical basis. Results indicate that combining gravity and elevation change measurements increase the accuracy of estimates of ice thickness changes.

Data Quality. Peer-reviewed publication is the most relied-upon assessment of the validity of a scientific accomplishment.

Data Sources. The Journal of Geophysical Research—Solid Earth published a paper by Wahr and Velicogna describing the accuracy possible when combining ICESat, GRACE, and GPS data.

Strategic Objective 2. Identify and measure the primary causes of change in the Earth system

Annual Performance Goal 2Y9. Increase understanding of the Earth's surface and how it is transformed and how such information can be used to predict future changes by meeting at least four of five performance indicators.

NASA achieved the annual performance goal with a rating of green. The Shuttle radar topography mission, which provided accurate topography in FY 2000, will expand available Satellite Radar Interferometry (InSAR) surface change measurements. Global topography maps called Digital Elevation Models (DEM) will advance gravity, hydrological, wind stress, and similar models.

In FY 2002, the station design for GPS monitoring of volcanoes provided tangible cost reductions. InSAR is the highest priority for the Solid Earth and Natural Hazards Program, according to the Solid Earth Science Working Group report. The synergy with geodetic GPS in monitoring high-resolution subsidence clearly demonstrated this. Multiyear InSAR averaging showed unexpected, never-before-seen deformation in the eastern Mojave Desert. Fixed-network GPS observations revealed periodic displacements in the Puget Sound/Cascadia trench region. The observation of periodic silent earthquakes was also a major revelation.

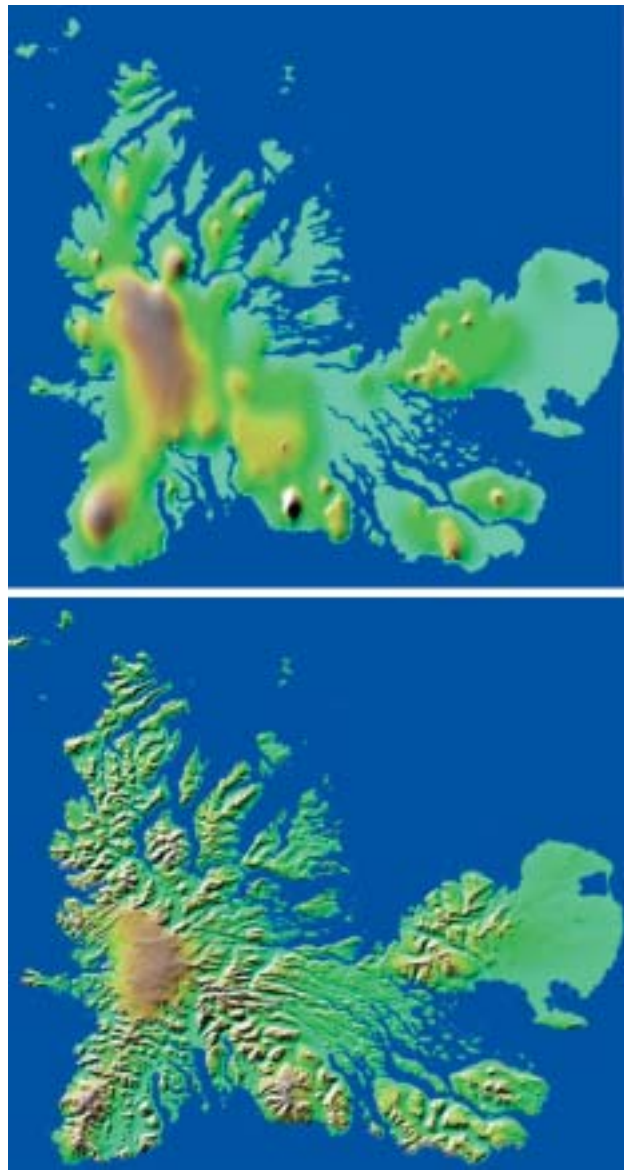
Indicator 1. Begin 5-year assessment of utility of completed Southern California Integrated GPS Network in understanding tectonic activities

Results. NASA began to assess the Southern California Integrated GPS Network (SCIGN) for its applicability to natural hazards. NASA developed the GPS technology within its global geodetic network and Solid Earth Science Program.

Data Quality. Peer-reviewed publication is the most relied-upon assessment of the validity of a scientific accomplishment.

Data Sources. The network homepage provides information about this project and a list of relevant publications at http://www.scign.org/.

Indicator 2. Perform a new integrated earthquake risk assessment of the Los Angeles basin based on continued measurement of accumulated strain in the southern California region



NASA maps the world with unprecedented precision

These images show exactly the same area: Kerguelen Island in the southern Indian Ocean. The top image was created using the best global topographic data set previously available, the U.S. Geological Survey's GTOPO30. In contrast, the more detailed bottom image was generated with data from the Shuttle radar topography mission, which collected enough measurements to map 80 percent of the Earth's landmass.

For parts of the globe, Shuttle radar topography mission measurements are 30 times more precise than previous topographical information, according to NASA scientists. Mission data will be a welcome resource for national and local governments, scientists, commercial enterprises, and members of the public. The applications are as diverse as earthquake and volcano studies, flood control, transportation, urban and regional planning, aviation, recreation, and communications. The data's military applications include mission planning and rehearsal, modeling, and simulation.

Results. The Rundle et al. and Tiampo papers, cited below, showed how to determine earthquake potential using an integrated model based on occurrence, fault

structure, and patterns. This information technology technique identified earthquake risk in California, successfully forecasting the location of three earthquakes greater than magnitude 5.

The Solid Earth and Natural Hazards Program funded the Bawden et al. study, which integrated the Southern California Integrated GPS Network and InSAR strain observations for the Los Angeles basin with well pumping data and fault geology. The study identified components of strain related to aquifer withdrawal and tectonically related strain. The study changed our view of strain estimates within the basin and identified human-caused sources of strain.

Data Quality. Peer-reviewed publication is the most relied-upon assessment of the validity of a scientific accomplishment.

Data Sources. Some examples of relevant journal publications include:

Rundle, J.B., K. F. Tiampo, W. Klein, and J.S. Sa Martins, Self-organization in leaky threshold systems: The influence of near-mean field dynamics and its implications for earthquakes, neurobiology, and forecasting.

Tiampo, K.F., J. B. Rundle, S. McGinnis, S.J. Gross, W. Klein, Mean Field Threshold Systems and Phase Dynamics: An application to Earthquake Fault systems, Europhysics Letters, in press.

Indicator 3. Continue providing the DEM of the Earth for scientific studies and practical applications

Results. NASA achieved the indicator. Shuttle radar topography data processing is proceeding according to schedule. NASA's Jet Propulsion Laboratory provided the National Imagery and Mapping Agency with North and South America DEM and other Department of Defense (DOD) high-priority information.

NASA made selected DEM available in two categories: limited access to principle investigators only and public access. A U.S. DEM at 30-meter resolution map is available to the public. This map and other data are available from the Earth Resources Observation system data center. NASA also made available high-resolution (30 meter) maps to the U.S. Geological Survey (USGS) for a volcano hazards response.

Data Quality. The Shuttle radar topography data exceeded specifications by a factor of two or better. Vertical errors appeared to be on the order of 5 to 10 meters and horizontal accuracy appeared to be 15 meters or better.

Data Sources. Project studies using global geodetic provided these error estimates. Shuttle radar topography data, links, and data policy are available at http://www.jpl.nasa.gov/srtm/. The EROS data center is also supporting the distribution of Shuttle radar topography data products in cooperation with NASA.

Indicator 4. Evaluate the utility of single-frequency GPS array technology for assessing volcanic deformation processes

Results. Single-frequency, or L1-only, receivers, proved not to be a cost-effective approach to GPS geodesy. University Navigation Signal Timing and Ranging Global Positioning System Consortium, a nonprofit organization that supports and promotes Earth science by advancing high-precision geodetic and strain techniques, is studying options to convert existing L1 sites to dual-frequency operation because of advancing commercial dual-frequency receiver technology and resultant cost advantages.

Data Quality. The data quality was good, but registered a factor of 2 to 10 times noisier than a standard dual-frequency GPS geodetic receiver. High sampling rates (less than 1 per second) proved not accurate enough.

Data Sources. Information on the L1 network and relevant links to data is available at http://www.unavco.ucar.edu/science_tech/dev_test/receivers/l1.html and http://charro.igeofcu.unam.mx/defnet/GPS_volcanoes.html.

Indicator 5. Characterize and model topographic evolution processes in at least two major tectonically active regions of the world and publish results

Results. The study areas characterized and modeled included the southern California region and the Andes. The southern California studies described how the faults, which deform the region, take up strain to form the significant features of the region. The Central Andes study used existing models, GPS measurements, geology, and other geophysical data sets.

Data Quality. Peer-reviewed publication is the most relied-upon assessment of the validity of a scientific accomplishment.

Data Sources. Publications about the southern California region included:

Peltzer, G., F. Crampe, S. Hensley, P. Rosen, November 2001: Transient strain accumulation and fault interaction in the Eastern California shear zone, Geology, volume 29, no. 11, 975-978.

Smith, B. and D. Sandwell, Coulomb stress accumulation along the San Andreas Fault System, Bulletin of the Seismological Society of America, submitted May 2002.

Strategic Goal 2. Expand and accelerate the realization of economic and societal benefits from Earth science information and technology

Strategic Objective 1. Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private-sector decisionmakers

Annual Performance Goal 2Y23. Provide regional decisionmakers with scientific and applications products and tools.

NASA achieved the annual performance goal with a rating of green. We prepared a strategy to solve practical problems facing the U.S. and the Earth. We identified 12 national applications on which to focus the future program. We partnered with Federal agencies and national organizations to apply the results of NASA research and development in remote sensing (observations) and science modeling (predictions) to the partner agency's needs for improved management or policy decision-making. Partner agencies include the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), the Federal Aviation Administration (FAA), and the Federal Emergency Management Agency.

Indicator 1. Conduct Program Planning and Analysis activities that result in the identification of five potential demonstration projects where user needs match NASA Earth Science Enterprise science and technology capabilities

Results. NASA's participation in these meetings led to development of 12 national priority applications areas: (1) energy forecasting, (2) agricultural competitiveness, (3) carbon management, (4) aviation safety, (5) homeland security, (6) community growth management, (7) community disaster preparedness, (8) public health, (9) coastal management, (10) biological invasive species, (11) water management and conservation, and (12) air quality management.

Data Quality. The Program Planning and Application process involved representatives from academia, science, industry, and policy sectors considered experts in their fields.

Data Sources. Information on the 12 national applications is located at http://esnetwork.org.

The National Academy of Sciences report, "Putting Science to Work and the U.S. Global Climate Change Program FY 2001: Our Changing Planet," provided guidance on applications where NASA results show potential to help decision makers.

Indicator 2. Develop two new joint demonstration projects with the user community

Results. NASA established three joint projects: wildfires, aviation, and public health.

Wildfires—NASA is supporting the U.S. Forest Service in benchmarking the capacity to use real-time access to Moderate Resolution Imaging Spectroradiometer (MODIS) data and other NASA provided measurements for fire management.

Data Quality. The Rapid Response Team is comprised of NASA, the MODIS science team, the University of Maryland, the U.S. Forest Service, the Earth Science Information Partnership, and Global Observations for Forest and Land Cover Dynamics. The team used the MODIS data from the Terra satellite and the Hyperion and Advanced Land Imager instruments on the Earth Observer–1 satellite.

Data Sources. References are available at http://eospso.gsfc.nasa.gov/earth_observ.html, on the Earth Observatory Web site at http://earthobservatory.nasa.gov, and the Rapid Response Team Web site at http://rapidfire.sci.gsfc.nasa.gov/products_rr.html.

Aviation—NASA collaborated with the FAA and the Radio Technical Commission for Aeronautics to establish guidelines for using remote sensing solutions (including Intelligence Reform Interferometric Synthetic Aperture Radar (IFSAR), lidar, and Shuttle radar topography). The guidelines addressed terrain databases for aviation worldwide. The International Civil Aviation Organizations is considering using the guidelines as the basis for an international standard. NASA supported the FAA and NOAA in monitoring volcano plumes and predicting global transport of related aerosols. NASA continued to assist the FAA in evaluating, verifying, and validating the use of sounding measurements provided by remote sensing satellites for aviation weather prediction.

Data Quality. The SC193 Working Group of the Radio Technical Commission for Aeronautics developed the terrain specifications. NASA's Jet Propulsion Laboratory provided continuous monitoring of volcanoes and reports information to the National Weather Service.

Data Sources. SC193 Working Group minutes, reports, and guidelines are available through the Radio Technical Commission for Aeronautics Web site at http://www.rtca.org. Volcano plume assessments are available through both the Jet Propulsion Laboratory at http://www.jpl.nasa.gov/earth/natural_hazards/volcanoes_index.html and the Earth Observatory site at http://earthobservatory.nasa.gov. Research at Langley Research Center supported advanced weather prediction; references are available at http://www.esnetwork.org and in the August 2002 issue of Earth Observation Magazine.

Public Health—NASA is working with the Centers for Disease Control and Prevention's (CDC) National Center for Environmental Health to benchmark NASA's Earth Observation System (EOS) data products and models of environmental indicators and parameters associated with disease initiation and transport. The data will be used as inputs in the CDC's Environmental Health Tracking Network, a first-of-its-kind public health decision support system designed to collect and analyze human environmental exposure information. State and local public health departments nationwide began demonstration projects using the network.

Data Quality. NASA Earth science observations and predictions are being evaluated for assimilation into the CDC's tracking network, especially data products from the Advanced Spaceborne Thermal Emission and Reflection Radiometer and MODIS sensor systems. These data products will be evaluated on their capacity to provide useful measures of human environmental exposure to State and local health departments.

Data Sources. Data sources and linkage processes is available at http://www.cdc.gov/nceh. Actual databases are not available for public view because they contain confidential medical information.

Strategic Goal 3. Develop and adopt advanced technologies to enable mission success and serve national priorities

Strategic Objective 3. Partner with other agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction

Annual Performance Goal 2Y28. Collaborate with other Federal and international agencies in developing and implementing better methods for using remotely sensed observations.

NASA achieved a rating of green. We expanded the use of remote sensing data through Federal partnerships with USGS, USDA, EPA, and with international partnerships with the Central American Commission on Environment and Development. NASA worked with the USGS to accelerate use of our results for predicting volcanoes and for monitoring land subsidence, biological invasive species, the transfer of the Earth Observer–1 satellite to the operational community, and the Landsat Data Continuity Mission. Results will also support the Federal Geographic Data Committee. NASA provided the U.S. Department of Agriculture solutions to wildfire management, carbon management, precision agriculture, and global crop assessment and prediction. EPA collaboration focused on Earth observations and predictions to support air quality management. With the Central American Commission on Environment and Development, the focus consisted of mesoscale biological corridor monitoring and assessment for sustainable ecosystem management in Central America.

Indicator 1. Continue to take advantage of collaborative relations with USGS, USDA and EPA to promote the use of remotely sensed data and information to accomplish U.S. strategic scientific, environmental and economic objectives

Results. The Agency has continued collaborations with Federal agencies including the USGS, USDA, and EPA. NASA and USGS are working to improve our ability to predict volcanic events by using InSAR measurements acquired on the Shuttle radar topography mission to monitor conditions leading to volcanic eruptions. In the field of land subsidence monitoring, our agencies demonstrated the use of change detection using Shuttle radar topography data to compare current elevations with USGS elevation data produced earlier. NASA and the USDA collaborate on wildfire management, supporting access to MODIS for fire management. NASA supported the USDA with plans for using remote sensing measurements in assessing the carbon sequestration capacity of the land and oceans, in support of the Administration's direction that USDA, Department of Energy, and EPA develop a carbon management and trading approach. We provided the USDA Foreign Agriculture Service with direct access capacity to use Earth-observing satellites to assist global crop assessments. NASA worked with the EPA on aerosol monitoring and associated science research to understand the processes of global and regional transport mechanisms.

Data Quality. The following professional documents describe the collaborations that took place.

Data Sources. Information about this indicator appeared in Solid Earth and Natural Hazards Working Group Report located at http://solidearth.jpl.nasa.gov/report.html and Earth Observation Magazine at http://www.eomonline.com.

Indicator 2. Demonstrate enhanced interoperability and interconnectivity of international remote sensing information systems and services through NASA's participation in the Committee on Earth Observation Satellites (CEOS) Working Group on Information Systems and Services (WGISS)

Results. The CEOS Working Group on Information Systems and Services collaborated on two international science initiatives, the Coordinated Enhanced Observing Period and the core sites work of the CEOS Working Group on Calibration and Validation, augmenting both projects' information systems requirements. NASA's contributions included the International Directory Network and a data-search-and-order capability of selected international sites. NASA monitored network performance among CEOS agency sites and led a task team investigating new technology and its potential applications to WGISS initiatives. NASA also coordinated the production of an online video to demonstrate WGISS capabilities at the World Summit on Sustainable Development.

Data Quality. Participating organizations, not the CEOS WGISS, monitor data quality.

Data Sources. A description of WGISS activities, participants, events and pointers to more information on the WGISS subgroups and task teams is located at http://wgiss.ceos.org.

Indicator 3. Demonstrate enhanced mission coordination and complementarity of remote sensing data through NASA's participation in the CEOS Working Group on Calibration and Validation

Results. NASA participated in the CEOS Working Group on Calibration and Validation. We contributed to the Optical Subgroup and the Chemistry Subgroup at a technical remote sensing level, as well as at the Plenary workgroup calibration and validation level with presentations of future sensing strategies.

Data Quality. Scientific working groups are reliable assessors of the validity of scientific activities.

Data Sources. An international Web site is maintained with information on the meeting calendar, membership, subgroups, documentation and reports, and the main CEOS Plenary organization and meetings. It may be reached at http://www.wgcvceos.org/.

Indicator 4. Demonstrate the establishment of an agreed international approach to an integrated global observing strategy for the oceans and the terrestrial carbon cycle through participation in the Integrated Global Observing Strategy - Partners

Results. The oceans and terrestrial carbon observing plans received approval and peer-reviewed journals published them.

Data Quality. Peer-reviewed publication is the most relied-upon assessment of the validity of a scientific accomplishment.

Data Sources. An article describing this plan is Cihlar, Josef, R. et al., 2002. Initiative to Quantify Terrestrial Carbon Sources and Sinks. EOS, Transactions, American Geophysical Union 83(1):1, 6-7.

Strategies and Resources to Achieve Goals

NASA's Earth science effort funds more than 1,500 scientific research tasks nationwide. Foreign-funded scientists from 17 nations work with U.S. researchers. The researchers develop Earth system models from Earth science data, conduct laboratory and field experiments, run aircraft campaigns, and develop new instruments, all of which expand our understanding of Earth. As we launch the first series of EOS satellites, more resources are going toward research and analysis of the new data.

The Earth science goals to key activities table shows the relationships among strategic goals, strategic objectives, and key activities. The Earth science resource estimates table gives budget authority figures for FY 1999 to FY 2002.

The Applications and Education Program bridges our research, analysis, and mission science investments. We seek to demonstrate new remote sensing data products for industry and regional and local decision makers. We also educate non-traditional Earth science customers, such as State, county, and regional managers and decision makers.

The Advanced Technology Program helps develop key technologies to enable future science missions. In addition to our baseline technology program that includes the New Millennium Program, Instrument Incubator, and Supercomputing Program, an Advanced Technology initiative identifies and invests in critical instrument, spacecraft, and information system technologies.

Development and Operations makes possible continuous, global observations from satellite-borne instruments. We have an integrated slate of spacecraft and in situ measurement capabilities; data and information management systems to acquire, process, archive, and distribute global data; and research and analysis projects to convert data into knowledge about Earth. These satellites are driving a new era of data collection, research, and analysis for which both the national and international Earth science community has been preparing in the last decade.

NASA pursued a targeted research program focused on specific science questions. We make research strategies that lead to definitive scientific answers and to effective applications for our Nation.

Research topics fall into three main categories: forcings, responses, and the processes that link the two, including feedback mechanisms. The approach is particularly relevant to climate change, a major Earth Science-related challenge facing our Nation and our world.

Our questions focus the research and development of our observational programs, analysis, modeling, and advanced technology activities: How is the Earth system changing, and what are the consequences for life on Earth? How is the global Earth system changing? What are the primary causes of change in the Earth system? How does the Earth system respond to natural and human-induced changes? What are the consequences of changes in the Earth system for human civilization? How can we predict future changes in the Earth system?

We will measure results in terms of the progress made toward answering these questions and extending the resulting knowledge, data, and technology to serve society. While these questions will be answered over years, the FY 2002 activities focused on the forces acting on the Earth system and its responses. NASA is pleased to play a leadership role in research and development of space-based solutions to exploring and understanding our home, Earth.

Cost-Performance Relationship

In achieving the strategic goals shown in the mapping Earth science goals to key activities table, during FY 2002, NASA incurred research and development expenses for the programs as follows. All of the resources went to research and development, and of this total approximately 37 percent of resources was spent on basic research, 7 percent on applied research, and 56 percent on development. For a description of the three research categories and a

Mapping Goals and Objectives to Key Earth Science Activities

Strategic Goal	Strategic Objective	Key Activity
Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth	Discern and describe how the Earth is changing	Development and Operations (EOS, Earth Explorers), Earth Science Research
	Identify and measure the primary causes of change in the Earth system	Development and Operations (EOS, Earth Explorers), Earth Science Research
	Determine how the Earth system responds to natural and human-induced changes	Development and Operations (EOS, Earth Explorers), Earth Science Research
	Identify the consequences of change in the Earth system for human civilization	Development and Operations (EOS, Earth Explorers), Earth Science Research
	Enable the prediction of future changes in the Earth system	Development and Operations (EOS, Earth Explorers), Earth Science Research
Expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology	Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private-sector decision makers	Applications and Education
	Stimulate public interest in and understanding of Earth system science and encourage young scholars to consider careers in science and technology	Applications and Education
Develop and adopt advanced technologies to enable mission success and serve national priorities	Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation	Advanced Technology
	Develop advanced information technologies for processing, archiving, accessing, visualizing, and communicating Earth science data	Advanced Technology
	Partner with other agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction	Applications and Education

Resource Estimates of Key Earth Science Activities

Key Activity	Budget Authority (in $ Millions)			
	FY 1999	FY 2000	FY 2001	FY 2002*
Development and Operations	974	970	911	801
Earth Science Research	252	286	350	339
Applications and Education	83	84	114	95
Advanced Technology	104	95	100	102
Institutional Support/Other	1	8	10	255
Total	**1,414**	**1,443**	**1,485**	**1,592**

*Beginning in FY 2002, Institutional Support is included in each Enterprise. FY 2002 reflects September Operating Plan.

summary of NASA's total research and development expenses, see the "Required Supplementary Stewardship Information—Stewardship Investments: Research and Development" schedule in Part III.

Budget-Performance Relationship

NASA's budget for Earth science was $1.592 billion in FY 2002. These resources enable NASA to carry out its three strategic goals. For this investment, NASA and its partners have made considerable progress in understanding the Earth system. NASA's Earth Science satellites, research, and technology development are the Nation's principal assets for studying patterns of change in the Earth system. NASA brings the vantage point of space to bear on these problems and with it the ability to integrate

observations with research and modeling to generate knowledge products needed by decision-makers.

With deployment of the EOS now underway, we are identifying organizations with the appropriate information infrastructure to apply NASA's Earth science results to help manage forest fires, coastal environments, and agriculture, infectious disease effects, aviation safety, and hurricane forecasting.

The potential socioeconomic benefits of many of these applications are significant. For example, by minimizing unnecessary emergency evacuation measures, improved hurricane predictions could provide as much as $40 million in cost savings for the Nation for each event. The value to our agriculture industry of an accurate El Niño forecast is estimated at $320 million per year. Similarly, improved weather forecasting can save as much as $8 million for individual energy companies by enabling utilities to better plan for anticipated energy requirements.

Our understanding of the Earth system is growing rapidly, as is our technological capability to make new observations and turn them into useful information products. The next 20 years will be even more exciting for Earth science, and will witness the evolution of a global environmental monitoring capability that will enable regional- and local-scale decisionmaking for a whole host of economic and societal endeavors.

We are giving our Nation a new window for looking at our home planet from the vantage point of space and we can use the knowledge gained to benefit our Nation and society at-large in unprecedented ways.

Biological and Physical Research

A key factor in improving life on Earth and extending it into space is a better understanding of how the elements—living and inanimate—crucial to our lives behave on Earth and in space. The conditions of space, particularly microgravity, allow us to examine fundamental phenomena—flame, cells, molecules—more closely and accurately than on Earth. We bring what we learn back to Earth to improve our terrestrial lives. Compiling data about the behavior of matter and organisms in space will allow humans to live healthily and productively in space.

Strategic Goal 2. Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology

Strategic Objective 1. Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community

Annual Performance Goal 2B4. Earn external review rating of green or blue by making progress in the following research focus areas as described in the associated indicators. Advance the scientific understanding of complex biological and physical systems

The Biological and Physical Research Advisory Committee rated progress on this annual performance goal as green. This goal was new in FY 2002.

Indicator 1. Prepare a Station research investigation on colloidal physics

Results. We prepared an experiment on fundamental physical properties of colloids, which are micron or submicron, spherical particles, suspended in a liquid medium. The experimental hardware arrived on the Station via the Shuttle (STS-100) and returned on STS-111. Researchers finished nearly 80 percent of the experiment before hardware issues halted work. Project engineers believe the failure was caused by a radiation event that damaged a memory module that held the computer startup sequence.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal. While the committee cannot yet access the published results on this indicator, the committee received a briefing on the interim progress.

Data Sources. Information is available at http://spaceresearch.nasa.gov/research_projects/ros/pcs.html.

Indicator 2. Maintain a peer-reviewed research program in complex systems physics and chemistry

Results. Complex systems physics and chemistry research was the fastest growing area in the Physical Sciences Research Program fluid physics discipline. It consisted of the subdisciplines of colloid science, complex fluids, and granular flows. Researchers explored the behavior of fluids and complex systems using the special characteristics of microgravity in space.

In FY 2002, fluid physics had 118 investigations. Complex systems physics and chemistry research accounted for 38 percent of those investigations, the largest percentage of the total within the fluid physics subdisciplines.

NASA funded 37 of the 202 research proposals received. Thirty-two percent of these grants were in the complex systems area.

Research in complex systems dominated early Station utilization in the physical sciences. Eight peer-reviewed investigations were developed for a variety of facilities including Expedite the Processing of Experiments to Space Station (EXPRESS) rack, the Microgravity Science Glovebox, and the Light Microscopy Module in the Fluids Integrated Rack.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The source of information for this goal is the 2002 Office of Biological and Physical Research (OBPR) Taskbook located at http://research.hq.nasa.gov/code_u/nra/current/NRA-01-OBPR-08/index.html.

Annual Performance Goal 2B5. Earn external review rating of green or blue by making progress in the following research focus areas as described in the associated indicators:

- Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures:

NASA's Biological and Physical Research Advisory Committee rated progress on this annual performance goal as blue, or substantially exceeding planned performance. This goal was new in FY 2002.

Indicator 1. Maintain a peer-reviewed research program in macromolecular and cellular biotechnology

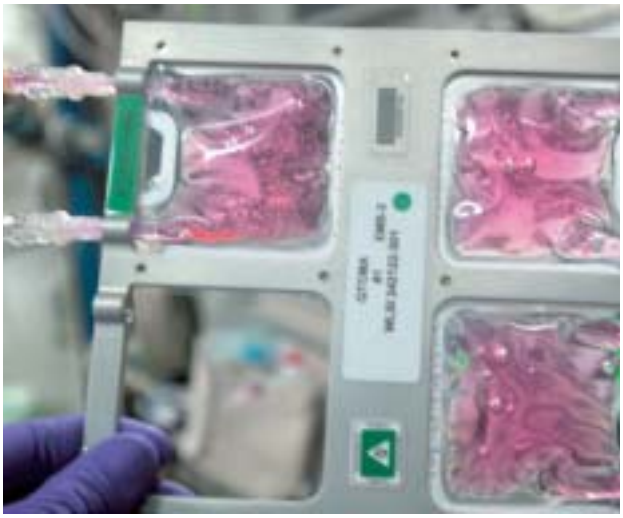
Results. The biotechnology discipline maintained the program, supporting about 50 investigations in cellular and macromolecular biotechnology. These numbers accounted for 83 percent of the investigations in the discipline compared with 83 percent in FY 2001. We started 23 investigations in cellular biotechnology and 20 in macromolecular biotechnology in FY 2002, all based on the peer-reviewed process, of which 29 represent new work.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The indicator data came from the FY 2002 OBPR Research Taskbook located at http://research.hq.nasa.gov/taskbook.cfm. It will be available to the public by February 28, 2003.

Indicator 2. Prepare Station research investigations in protein crystallization and three-dimensional tissue culture

Results. NASA conducts protein crystallization experiments in space to improve our understanding of the structures of important proteins. That new understanding can help improve medical therapies or be used in other applications. One example is the protein thaumatin. Thaumatin is a protein isolated from a West African plant. It is 2,000 to 3,000 times sweeter than sucrose, or sugar, and is an approved sweetener or flavor enhancer in Japan, the European Union, and the United States. A detailed understanding of the atomic structure of thaumatin may aid the development of artificial sweeteners. Thaumatin crystals obtained from the Enhanced Gaseous Nitrogen Dewar on stage 2A.2b/3A and on stage 5A/5A.1 diffracted to a higher resolution than any crystals ever grown on the ground. The space-grown crystals provided 50 percent more data than the best ground-grown crystals. Obtaining improved crystals on two separate stages aboard the Station demonstrated the reproducibility of our results.



NASA improves the study of cell growth with microgravity

Human cell tissue research that could contribute to the study of cancer and other diseases kept the Expedition 4 crew busy aboard the International Space Station. Cell research using the Cellular Biotechnology Operations Support System is one of the most crew-intensive experiments. It requires injecting cells into 32 containers of nutrient solution, incubating them, and then periodically removing nutrient solution for analysis and re-injecting fresh growth fluid. At the end of the experiment, the crew must stop growth and inject a preservative into the cell containers.

Cells grown on this mission include human renal cells, blood cells, and tonsillar cells. In microgravity, cells can be cultivated into healthy, three-dimensional tissues that retain the form and function of natural, living tissue. On Earth, studying normal growth and replication of human cell tissue outside living organisms is difficult, because most cells cultivated outside the body form flat, thin specimens that limit insight into the way cells work together.

In FY 2002, three Shuttle missions delivered protein crystallization experiments to the Station. STS-108 delivered the Single-locker Thermal Enclosure System/Protein Crystallization Apparatus for Microgravity (STES/PCAM), which included 8 proteins and 753 samples (455 were solution optimizations samples) for 5 investigators. STS-110 delivered the Enhanced Gaseous Nitrogen Dewar, containing 10 proteins and 378 samples for 5 investigators. STS-111 delivered a STES/PCAM assembly containing 10 proteins and 378 samples for 8 investigators.

Another set of protein crystallization experiments considered three-dimensional tissue cultures. Cells associate in complex, three-dimensional groupings to form living tissue. When researchers try to replicate this natural growth in ground-based laboratories, they find that the cultivated cells form flat, thin specimens. Because these specimens do not accurately represent cell behavior, they are of limited use to researchers. On the other hand, cells grown in microgravity grow three dimensionally and more closely resemble cells found in living bodies. The Cellular Biotechnology Operations Support System provides the first on-Station hardware dedicated to

cultivating cells which is used by multiple investigators to accomplish their scientific objectives.

Cellular biotechnology experiments were completed on Station research Expeditions 3, 4, and 5. Among the cells grown on orbit were ovarian cancer cells, colorectal cancer cells, immune system cells, and liver cells. Analysis of these cells is under way. One Station experiment used human tonsil tissue to model human immuno-deficiency virus. Human tonsil tissue that is used to grow the virus on the ground in NASA-developed bioreactors exhibits deficits in immune signaling. The space experiments used the same tonsil tissue to determine the effect of microgravity. These experiments will further explain the mechanisms involved in the generation and synthesis of antibodies. There is suggestive evidence that humans in space may exhibit the beginnings of a decline in immunity.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Information on biotechnology research is available at the following Web sites: http://spaceresearch.nasa.gov/research_projects/ros/pcgstes.html and http://spaceresearch.nasa.gov/research_projects/ros/ pcgegn.html.

Increment 3 and 4 investigation abstracts are located at http://spaceresearch.nasa.gov/research_projects/ros/cboss.html and http://spaceresearch.nasa.gov/research_projects/ros/cbosspast.html, respectively.

Strategic Objective 2. Develop strategies to maximize scientific research output on the Station and other space research platforms

Annual Performance Goal 2B10. In close coordination with the research community, allocate flight resources to achieve a balanced and productive research program.

NASA's Biological and Physical Research Advisory Committee rated progress on this annual performance goal as green. This performance goal was new in FY 2002. Station research continued according to plan. We made substantial progress in prioritizing research and conducted an extensive review to better define research management options. Although NASA did not begin procurement activities leading to a nongovernmental organization for Station research as required on several indicators, we merited a score of green because we made substantial progress toward creation of an appropriate model for Station research management.

Indicator 1. Assume management responsibility for the Station research budget

Results. The biological and physical research effort assumed management responsibility for the Station research budget and initiated quarterly reviews of relevant research capability development.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA's initial operating plan letter of February 15, 2002, established the change in management responsibilities.

Indicator 2. Begin procurement activities leading to a nongovernmental organization for Station research

Results. The biological and physical research effort did not begin procurement activities for a nongovernmental organization for Station research. In light of extensive restructuring of Station development and a reprioritization of planned Station research, the Agency chose to revalidate research requirements for the Station and to conduct an extensive review process to define Station utilization.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The status of this effort will be updated on the following Web site as appropriate: http://spaceresearch.nasa.gov.

Indicator 3. Coordinate scientific community participation in the definition of Station research

Results. We coordinated scientific participation in the definition of Station research through the Research Maximization and Prioritization Task Force, completion of a National Research Council report on Station research, and through an open and competitive research announcement process.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The data sources are the Research Prioritization and Maximization Task Force report and a prepublication copy of the report of the National Research Council's Task Group on Research on the Station.

Indicator 4. Balance resource allocations and flight opportunities through a Partner Utilization Plan

Results. We maintained a baseline partner utilization plan in FY 2002.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The baseline partner utilization plan is available at http://iss-www.jsc.nasa.gov/ss/issapt/rpwg/01_01_ 17_PUP_Approved_by_SSUB.xls.

Indicator 5. Prepare peer-reviewed and commercial research investigations for execution on STS-107

Results. Despite schedule slips for STS-107, NASA prepared peer-reviewed and commercial research investigations. The complete suite of experiments is located at http://spaceresearch.nasa.gov/sts-107/index.html.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. A review of about 80 STS-107 mission experiments is available at http://spaceresearch.nasa.gov/sts-107/index.html.

Indicator 6. Conduct early research on the Station

Results. Preceding indicators show preliminary results from Space Station experiments. NASA conducted more than 50 investigations in FY 2002, using 5 research racks. The Human Research Facility rack 1 supported human life sciences investigations. It contained a mass spectrometer, ultrasound equipment, portable computer, workstation, and cooling stowage drawer. EXPRESS rack 1, activated on STS-100, supported two continuously powered acceleration measurement experiments: the Microgravity Acceleration Measurement System and the Space Acceleration Measurement System. EXPRESS rack 2, activated in FY 2001, supported experiments such as colloids in space and zeolite crystal growth. EXPRESS rack 4, which we activated in August, supported the storage freezers, ARCTIC 1 and 2. EXPRESS rack 5 supported commercial research experiments. NASA activated the Microgravity Science Glovebox during Expedition 5 to support the Solidification Using a Baffle in Sealed Ampoules experiment and Pore Formation and Mobility Investigation.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Reports on Station research are available at http://spaceresearch.nasa.gov.

Strategic Goal 3. Enable and promote commercial research in space

Strategic Objective 1. Provide technical support for companies to begin space research

Strategic Objective 2. Foster commercial research endeavors with the Station and other assets

Annual Performance Goal 2B11. Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least three of four performance indicators.

In FY 2002, NASA's Biological and Physical Research Advisory Committee rated progress on this annual performance goal as green. NASA met its performance targets for commercial research in space in FY 2001, FY 2000, and FY 1999.

Indicator 1. Maintain or increase non-NASA investment in commercial space research during the FY 2002 transition from a Shuttle-based to a Station-based program

Results. Non-NASA investment to the commercial space centers remained steady compared with FY 2001, recording a negligible 0.3 percent drop.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Commercial space centers provided data, either directly or through their various reports such as proposals, business operating plans, and annual reports. The figures for FY 2002 are still estimates because the cooperative agreement year for the commercial centers ends on October 31. Information about the centers is available at http://spd.nasa.gov.

Indicator 2. Maintain a ratio of non-NASA funding to NASA funding of not less than 3 to 1 in FY 2002

Results. The ratio of non-NASA funding to NASA funding was about 1.4 to 1 in FY 2002; however, this ratio reflects an accounting change. Because of a change in the budget structure, NASA now includes funding for Station research equipment development as part of its contribution. This change results from NASA's efforts to improve management and accountability in Station research. If the ratio were calculated using the budget structure in place when this indicator was established, the ratio would be very close to 3 to 1. In effect, the existing ratio was maintained as required by the indicator. NASA tracks this estimated ratio as a measure of the strength of commercial participation in space research. NASA has firm figures for its expenditure, but is still collecting reports of funding by commercial partners. The ratio will be reported in its final form by January 15, 2003.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Commercial space centers provided progress data through reports such as proposals, business operating plans, and annual reports. Information about the Commercial space centers is available at http://spd.nasa.gov.

Indicator 3. Ensure that one of the 39 product lines currently under investigation is brought to market, available for commercial purchase, in FY 2002

Results. Not one but two products came to market. The Space Rose fragrance product that the Wisconsin Center for Space Automation and Robotics and its partner, International Flavors and Fragrances, discovered on STS-95 appeared in a second product this fiscal year. Commercial center affiliate Flow Simulation Services began marketing its Arena-flow software to the metal

casting manufacturing industry; it also has future applications in food and pharmaceutical production and in aerosol drug delivery. NASA's partners also made progress in several other research areas including bacterial growth research and research on a drug to control bone loss.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. International Flavors and Fragrances reported the marketing of the fragrance to NASA through their partners at the Wisconsin Center for Space Automation and Robotics. The Solidification Design Center reported Arena-flow's marketing to NASA.

Commercial space centers provided data in the form of proposals, business operating plans, and annual reports. Information about the centers is available at http://spd.nasa.gov.

Indicator 4. Enable at least 10 new, active industrial partnerships to be established with the space product development commercial space centers

Results. We gained 35 new industrial partners in FY 2002, easily surpassing our goal of 10. The companies involved were active in a variety of fields including technology development, human-interest proteins, paper products, education, and computer systems. Companies must give permission for their names to be available. Otherwise, the information is proprietary.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Commercial space centers provided data, either directly or through reports such as proposals, business operating plans, and annual reports. Information about the centers is available at http://spd.nasa.gov.

Strategies and Resources to Achieve Goals

The biological and physical research resource estimates table gives budget authority figures for FY 1999 to FY 2002.

In FY 2002, NASA's biological and physical research effort officially took over management and funding responsibility for the Station Research Capabilities. This increased the overall budget by 107 percent.

Bioastronautics. Bioastronautics represented 15 percent of the budget. It includes the Countermeasures and Advanced Human Support Technology Programs. The Countermeasures Program identifies ways to prevent or reduce the risks associated with living in space. The Advanced Human Support Technology Program develops new technologies and next-generation systems for humans in space.

Physical Sciences Research. Physical Sciences Research (previously the Microgravity Research Program) represented 28 percent of the budget. Combining cutting-edge experimental facilities with long-duration access to low-Earth orbit allows NASA to overcome limitations of gravity and enables new scientific discoveries. The program's on-orbit focus includes fundamental research, creating a knowledge base for future mission technologies, and returning tangible value from investment in space. The ground-based program supports experimental, theoretical, and numerical models that develop the foundation for the on-orbit program.

Fundamental Space Biology. The Fundamental Biology Program, representing 11 percent of the major program budget, studies biological processes through on-orbit and ground-based research. The microgravity environment of space offers an unparalleled environment for research on cell growth, tissues, and biology. Our research has led to new strategies for probing disease processes and developing medical countermeasures, and has advanced our knowledge of cellular processes.

Space Product Development. The Space Product Development Program had the smallest budget at 4 percent. It provides commercial researchers access to space for development of new or improved products and services for use on Earth. NASA and industry fund the commercial space centers that perform biotechnology, agribusiness, and materials research. The commercial product goals include improved crop development, enhanced refining processes for better fuel efficiency, improved drug development, improved drug production rates, and advanced materials for hip or knee replacements that are more durable and less likely to be rejected by the body.

Cost-Performance Relationship

In achieving the strategic goals shown in the mapping biological and physical research goals to key activities table, during FY 2002, NASA incurred research and development expenses for the programs as follows. All of the resources went to research and development, and of this total approximately 29 percent was spent on basic research, 58 percent on applied research, and 13 percent on development. For a description of the three research categories and a summary of NASA's total research and development expenses, see the "Required Supplementary Stewardship Information—Stewardship Investments: Research and Development" schedule in Part III.

Budget-Performance Relationship

NASA's budget for biological and physical research was $824 million in FY 2002. This includes funds to develop research equipment, support commercial space centers, and provide grants to investigators for ground and flight

Mapping Goals and Objectives to Key Biological and Physical Research Activities

Strategic Goal	Strategic Objective	Key Activity
Conduct research to enable safe and productive human habitation of space	Conduct research to ensure the health, safety, and performance of humans living and working in space	Bioastronautics*
	Conduct research on biological and physical processes to enable future missions of exploration	Physical Sciences Research and Fundamental Space Biology
Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology	Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community	Physical Sciences Research and Fundamental Space Biology
	Develop strategies to maximize scientific research output on the Station and other space research platforms	Space Product Development
Enable and promote commercial research in space	Provide technical support for companies to begin space research	Space Product Development
	Foster commercial research endeavors with the Station and other assets	Space Product Development
	Systematically provide basic research knowledge to industry	Space Product Development
Use space research opportunities to improve academic achievement and the quality of life	Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets	All
	Engage and involve the public in research in space.	All

* In the FY 2002 structure, Bioastronautics was funded as separate elements: Biomedical Research and Countermeasures and Advanced Human Support Technology.

Resource Estimates of Key Biological and Physical Research Activities

Key Activity	Budget Authority (in $ Millions)			
	FY 1999	FY 2000	FY 2001	FY 2002*
Bioastronautics	85	87	100	120
Physical Sciences Research	114	109	130	228
Fundamental Space Biology	41	38	40	92
Space Product Development	15	14	14	32
Multi-User System and Support**	0	0	0	165
Institutional Support/Other	9	27	29	187
Total	**264**	**275**	**313**	**824**

*Beginning in FY 2002, Institutional Support is included in each Enterprise. FY 2002 reflects September Operating Plan.
**Multi-User System and Support is a new category developed when the International Space Station Research Capabilities was transferred to Biological and Physical Research.

research. In selecting investigations and projects to support—and ultimately for access to space—NASA follows peer-review processes to ensure the competitiveness and quality of the research. NASA engages in substantial cooperation with the National Institutes of Health and other Federal Government entities with overlapping interests in space research. NASA's biological and physical research focuses on those investigations that require access to space or that are required to ensure a safe human presence in space. Thus, a primary output of the Nation's investment in NASA's biological and physical research is facilitating human presence in space. This presence enables significant research outcomes as described above as well as the pursuit of other national priorities.

NASA recently requested that a NASA Advisory Council task force review the Station research plan to recommend priorities for maximizing return on research investment. The Research Maximization and Prioritization Task Force

recommended a series of priorities for Station research by discipline. The task force review, based on past performance in these disciplines as presented by NASA, as well as National Research Council progress reports, recommended directions for our biological and physical research. NASA is applying these priorities to maximize return on resources. The Agency's FY 2004 budget request is a first step in this process, with planning expected to continue through development of the FY 2005 budget request.

Human Exploration and Development of Space

To conduct space-based research that can improve life on Earth, and to seek other forms of life far beyond Earth, we must be able to safely travel into space and live there. The Shuttle provides safe human access to space and the capability for launch and in-orbit repair of spacecraft that require human intervention. The Station provides an orbiting laboratory where humans from many nations together conduct a multitude of precedent-breaking experiments, including those that investigate how we withstand and adapt to space conditions. The following are highlights of our FY 2002 efforts to achieve key goals. The remainder of our goals, objectives, and achievements are discussed in Part II.

Strategic Goal 2. Enable humans to live and work permanently in space

Strategic Objective 1. Provide and make use of safe, affordable, and improved access to space

Annual Performance Goal 2H6. Assure public, flight crew, and workforce safety for all Space Shuttle operations.

The Space Shuttle Program continues its outstanding safety record. Overall safety has steadily increased; since 1992, we have reduced estimated risks during launch by 80 percent and in-flight anomalies by 70 percent. The safety of the Space Shuttle Program team nationwide is equally important. The program's workplace is far safer than the industry average and continues to improve. Current safety performance for recorded injuries is 75 percent better than the industry average. We have enhanced Kennedy Space Center security since the recent terrorist attacks. The security enhancement involved the land, sea, and air assets of several Federal agencies. Daily contact between NASA test directors and payload integration managers and the willingness of the entire Kennedy team to embrace the necessary changes eased the integration of the enhancements into Shuttle and payload processing operations. Other FY 2002 safety measures included repairing a cracked hydrogen vent line on the mobile launch platform and small cracks on the orbiter's main propulsion system fuel flow liners. We earned an overall rating of green for this performance goal.

Indicator 1. Achieve zero type A or B Mishaps in FY 2002.

Results. There were no type A or B mishaps for the Space Shuttle Program this fiscal year. Type A mishaps are those that result in property, facilities, or equipment damages of $1 million or more or in the death of a person. Type B mishaps are those that result in property, facilities, or equipment damages between $250,000 and $1 million or in the permanent disability of one or more persons, or the hospitalization of three or more persons. This is a new indicator.

Data Quality. Mishap data accurately reflect performance, reflect achievements accomplished in FY 2002, and align with planned performance.

Data Sources. Data were obtained from Program Requirements Control Board directives and the host Center's Program Management Council.

Indicator 2. Achieve an average of eight or fewer flight anomalies per Space Shuttle mission.

Results. There were five flight anomalies on STS-108, eight on STS-109, seven on STS-110, and four on STS-111. This yields an average of six flight anomalies in FY 2002, well under the goal but slightly higher than the average in FY 2001. None of these flight anomalies hindered mission success.

Data Quality. Flight anomaly data accurately reflect performance achievements in FY 2002. The reporting of both individual and average mission results is consistent with reporting of past annual performance indicators.

Data Sources. Data were obtained from Program Requirements Control Board directives and the Host Center Program Management Council.

Strategic Objective 2. Operate the Station to advance science, exploration, engineering, and commerce

Annual Performance Goal 2H11. Demonstrate Space Station Program progress and readiness at a level sufficient to show adequate readiness in the assembly schedule.

In FY 2002, NASA completed three missions to the Station. Two other flights were delayed until early FY 2003 because of Shuttle and ground-support equipment issues. Two of the completed missions were science missions, delivering experiments and racks of scientific equipment. The third NASA mission delivered the integrated truss segment and the mobile transporter that has become the manipulator servicing system. For this performance goal, we earned a rating of green.

Indicator 1. Conduct monthly status reviews to show maturity and preparation of flight readiness products. Maintaining 80 percent of defined activities are within scheduled targets (green).

Results. The Space Station Program conducts progress reviews on the first Friday of every month and issues a flight-readiness summary at the quarterly Program

Management Councils. In FY 2002, more than 80 percent of the defined activities met scheduled targets.

Data Quality. A flight-readiness summary chart shows the flight status of missions for the entire performance period and product maturity and resolution of issues for planned missions more than 2 years from now. Given Station complexity and the number of integration tasks required, significant cost, schedule, and technical challenges have occurred, but workarounds and efficiencies have maintained the schedule.

Data Sources. A flight-readiness summary for upcoming flights is available under the annual performance goal 2H11 link at http://iss-www.jsc.nasa.gov/ss/issapt/pmo/gprametrics.htm.

Annual Performance Goal 2H12. Successfully complete 90 percent of the Station-planned mission objectives.

The Space Station Program completed 90 percent of the primary mission objectives during the three flights launched during FY 2002. The objectives are set in the mission objectives letters for each flight, which include two utilization flights (UF1 and UF2) and the 8A assembly flight. During the UF1 flight, failure of a hose prevented the crew from demonstrating the ability to transfer oxygen. The crew later accomplished the task on flight 8A. Despite this setback, we earned an overall rating of green for this performance goal.

Indicator 1. Achieve 90 percent on-orbit mission success for planned Station assembly and logistics activities on the Shuttle flights scheduled for FY 2002. This indicator is determined from the sum total of the successfully accomplished primary mission objectives divided by the total number of mission objectives per year.

Results. The Space Station Program continues to exceed 90 percent of its primary mission objectives. It also completed several get-ahead tasks during FY 2002 for future missions. As noted in annual performance goal 2H11 above, despite many technical challenges, NASA was able to complete primary mission objectives because of training, innovative workarounds, redundant or robust system designs, and contingency planning.

Data Quality. The data come from postflight reports, which document tasks completed during each flight. In addition to the mission primary objectives, the reports identify the added tasks and the get-ahead tasks. There are no data limitations.

Data Sources. The data are provided at URL http://iss-www.jsc.nasa.gov/ss/issapt/pmo/gprametrics.htm under the 2H12 link. They include postflight review reports for both UF1 and UF2 and the 8A assembly flight.

Strategic Goal 3. Enable the commercial development of space

Strategic Objective 2. Foster commercial endeavors with the Station and other assets

Strategic Objective 3. Develop new capabilities for human space flight and commercial applications through partnerships with the private sector

Annual Performance Goal 2H21. Continue implementation of planned and new Shuttle privatization efforts and further efforts to safely and effectively transfer civil service positions and responsibilities to private industry.

This is the first year for this metric. We achieved the performance indicators for extending the space flight operations contract and developing privatization options. In keeping with the terminology used in the President's Management Agenda (PMA), future performance plans will refer to this activity as competitive sourcing. Our rating for this performance goal is green.

Indicator 1. Negotiate an extension of the Space Flight Operations Contract (SFOC) by the end of the fiscal year.

Results. The Government unilaterally exercised the first two-year contract option on August 1, 2002. Bilateral negotiations continue for additional changes to the contract. We expect to complete this contract change in October 2002.

Data Quality. Space flight operations contract data accurately reflect FY 2002 performance.

Data Sources. The performance data were obtained from normal program reporting and from Mod 806 of NASA contract NAS9-20000 dated August 1, 2002.

Indicator 2. Develop criteria and establish options with private industry on Shuttle privatization that assure continued safe operation of the Space Shuttle. Engage aerospace contractor community in evaluation of options.

Results. A RAND Corporation-led task force of private-sector business specialists identified business models suitable for competitive sourcing of Shuttle operations, defined requirements for success of each potential business model, and evaluated the strengths and weaknesses of each model. Among the task force's findings are the following:

- Safe operations must remain the top priority.
- The transfer of civil service personnel to a private sector company has limited viability.
- Market demand for the Shuttle exists, but is very limited.
- Liability concerns affect Space Shuttle Program asset ownership, but not operations.
- The Space Shuttle Program remains structured as a development program that is not conducive to independent operation by a private firm.

The study also found a tight linkage among the Shuttle, the Station, and Space Launch Initiative Programs. Any major decision in one program could profoundly affect the others.

NASA upgrades the world's most famous "eye in the sky"

In March 2002, the versatile Shuttle was a repair shop. Here, the Hubble Space Telescope is docked in the bay of Shuttle Columbia. During this space walk, Astronauts James Newman and Michael Massimino removed the Faint Object Camera to accommodate the new Advanced Camera for Surveys. Compared to the previous capability, this new camera covers twice the area and offers twice the sharpness. It is up to five times more sensitive to light. By April, Hubble was treating the world to the most spectacular views of the universe yet.

Further, a decision on the future of the Space Shuttle Program could significantly alter the options available for future human space exploration, not to mention potential military space requirements. Each model comes with numerous strengths, weaknesses, and hurdles. We are reviewing all. A decision on a course of action is expected in February 2003.

Data Quality. Competitive sourcing data accurately reflect performance and achievements in FY 2002.

Data Sources. The performance data were obtained from normal program reporting. The Space Shuttle Competitive Sourcing Task Force report is available at http://www.rand.org/scitech/stpi/NASA/.

Strategies and Resources to Achieve Goals

The mapping goals to key human exploration and development of space activities table shows the relationships among strategic goals, strategic objectives, and key activities.

International Space Station. The Station is a permanent human habitat in low-Earth orbit. It is a laboratory for basic and applied research into the limits of human performance in space; the secrets of cell and developmental biology, plant biology, human physiology, combustion science, materials science, and physics; and the uncharted territories of space industry and commerce. The Station also provides a platform for long-term observation of the Earth's surface and atmosphere. Experience gained from using the Station will guide the direction of space exploration, which is crucial to our mission to explore, use, and enable the development of space for human enterprise.

The Station is in its final phase of assembly. With the key components provided by Canada, Russia, and the United States currently in orbit, the Station is already the most capable spacecraft ever deployed. We will continue to deploy the U.S. components through early 2004, after which components will primarily come from our partner nations. With the elements on orbit already exceeding performance expectations and with most of the remaining U.S. hardware now in final preparation at the launch site, vehicle design and development risk has largely been retired.

NASA identified potential Space Station Program cost overruns in FY 2002. We took steps to contain costs by limiting future growth while keeping core functionality. Note that budget reductions since FY 2001 reflect not only cost containment, but also development activities coming to an end and the transfer of research funds beginning in FY 2002 to the Biological and Physical Research Enterprise.

Space Shuttle. The Shuttle, the most versatile launch vehicle ever built, is a science laboratory, a taxi and delivery van, a repair shop, and essential to the assembly and operational support of the Station. The Shuttle Program also launches numerous cooperative and reimbursable payloads owned by foreign governments and international agencies. The primary goals of the program are to fly safely, meet the flight manifest, improve customers' support, and improve the system. Reducing program costs at the same time is a continuing imperative. The program budget is stable and represents a continued restrained fiscal approach. Vendor loss, high failure rates of aging components, high repair costs of Shuttle-specific devices, and negative environmental impacts continue to pose significant challenges.

Launch Services. The Launch Services Program provides two services: Payload Carriers and Support provides technical expertise, facilities, and capabilities for payload buildup, test, and checkout and for integrating and installing payloads into the launch vehicle. Expendable Launch Vehicle Mission Support provides

technical oversight of launch services, mission analysis, and feasibility assessments for NASA payload customers. It also identifies and makes available secondary payload opportunities. This budget is stable.

Space Operations. Space Operations provides command, tracking, and telemetry services between ground facilities and flight vehicles, research and development to adapt emerging technologies to NASA operational requirements, and spectrum management for all NASA missions. Reliable electronic communications are essential to the success of every NASA flight mission.

The human exploration and development of space resource estimates table gives budget authority figures for FY 1999 to FY 2002.

Cost-Performance Relationship

In achieving the strategic goals shown in the mapping human exploration and development of space goals to key activities table, during FY 2002, NASA incurred research and development expenses for the programs as follows. Nine percent of total resources were spent on research and development, with the remaining 91 percent spent on other expenses. Of the research and development resources, about 64 percent were for basic research and 36 percent for applied research; no resources went to development. For a description of the three research categories and a summary of NASA's total research and development expenses, see the "Required Supplementary Stewardship Information—Stewardship Investments: Research and Development" schedule in Part III of this report.

Budget-Performance Relationship

NASA's human exploration and development of space effort continues to demonstrate safe, reliable performance in support of Agency objectives, providing space transportation, accommodations, and other flight support at a significantly lower annual cost than that of a decade ago. This helps us maximize funding for research. Shuttle annual operations costs, including a continuing upgrades effort that will safely carry the program into the next decade, are roughly 40 percent less, and Space Communications costs roughly 50 percent less, than they were in the early 1990s.

The Space Shuttle Program successfully completed four of seven flights planned for FY 2002. Safety concerns with orbiter main propulsion flow liners caused us to delay three flights until FY 2003. Because development costs for these flights are incurred over multiple years, there were no significant savings in FY 2002. The shift will result in minor increases to budget requirements in later years. The four missions accomplished in FY 2002 were fully successful, increasing research returns from the Station and Hubble. These research returns would be impossible without the unique capabilities of the Shuttle to provide human interaction in the delivery, assembly, and servicing of orbital systems. Given the reduced flights, the launch cost per pound for a pro rata share of the Shuttle Program in FY 2002 would be twice that of the Titan IV, which has comparable lift capability. However, since there is no other system in the world that could have accomplished the Shuttle's FY 2002 missions, it is not possible to assess price competitiveness.

Cost plans, conducted by NASA, were maintained for development efforts and safety and supportability upgrades that will improve Shuttle operations and prevent obsolescence into the next decade. These efforts met performance and cost goals.

To ensure the continued technical competence of its especially skilled workforce, the Space Shuttle Program continued to explore a variety of changes in the way it operates the Shuttle. One approach is competitive sourcing—a key component of the President's Management Agenda. The challenge is determining whether new arrangements can achieve greater safety and reliability at a lower cost. Competitive sourcing could reduce the number of NASA civil servants in operations. If contractor staff prove to be less expensive while equally safety-conscious and reliable, this could free up resources for research and development. While this would not affect current Shuttle Program budgets, a private organization with greater flexibility to make business decisions that increase efficiency could reduce future cost growth. We are revising the Integrated Space Transportation Plan, which will provide an orderly transition from the Shuttle to a future vehicle.

The Space Shuttle Program continues its outstanding record of safety and customer support. Shuttle safety performance has steadily increased in the past decade. Since 1992, estimated risks during launch have fallen 80 percent, and the number of Shuttle problems in flight has dropped by about 70 percent.

Space Station Program annual funding requirements continue to decline, reflecting the transition from a development program to an operational one. Performance problems in FY 2001 resulted in major program changes and content reductions, resolved through an aggressive plan that radically changed program and financial management. In FY 2002, Congress appropriated $96 million less than the President's FY 2002 budget request. Yet the program is still on schedule for U.S. Core Complete in early 2004 (adjusted for Shuttle launch delays) and began FY 2003 with unencumbered reserves.

In focusing on the U.S. Core Complete configuration and working to resolve financial and management deficiencies, the Space Station Program has developed sound documentation and cost-estimating techniques. Two independent review teams have now validated the Station life cycle. NASA lacks previous significant experience in operating a space station. As cost estimates continually

Mapping Goals and Objectives to Key Human Exploration and Development of Space Activities

Strategic Goal	Strategic Objective	Key Activity
Explore the space frontier	Invest in the development of high-leverage technologies to enable safe, effective, and affordable human/ robotic exploration*	Technology and Commercialization Initiative*
	Conduct engineering research on the Station to enable exploration beyond Earth orbit*	Technology and Commercialization Initiative*
	Enable human exploration through collaborative robotic missions	Launch Services
	Define innovative human exploration mission approaches*	Technology and Commercialization Initiative*
	Develop exploration/commercial capabilities through private sector and international partnerships*	Technology and Commercialization Initiative
Enable humans to live and work permanently in space	Provide and make use of safe, affordable, and improved access to space	Space Shuttle, Launch Services
	Operate the Station to advance science, exploration, engineering, and commerce	Space Station
	Ensure the health, safety, and performance of humans living and working in space	Transferred to the Biological and Physical Research Enterprise
	Meet sustained space operations needs while reducing costs	Space Operations
Enable the commercial development of space	Improve the accessibility of space to meet the needs of commercial research and development	Space Station, Launch Services**
	Foster commercial endeavors with the Station and other assets	Space Station
	Develop new capabilities for human spaceflight and commercial application through partnerships with the private sector	Space Shuttle, Technology and Commercialization Initiative*
Share the experience and benefits of discovery	Engage and involve the public in the excitement and the benefits of—and in setting the goals for—the exploration and development of space*	Technology and Commercialization Initiative*
	Provide significantly more value to significantly more people through exploration and space development efforts	Space Station
	Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets	Office of Space Flight, Technology and Commercialization Initiative*

*Denotes strategic objectives that do not have annual performance goals because of a general funding reduction and the cancellation of the Technology and Commercialization Initiative
**Formerly called Payload and ELV (Expendable Launch Vehicle)

Resource Estimates of Key Human Exploration and Development of Space Activities

Key Activity	Budget Authority (in $ Millions)			
	FY 1999	FY 2000	FY 2001	FY 2002*
Space Station	2,300	2,338	2,128	1,721
Space Shuttle	2,998	3,000	3,119	3,270
Launch Services	71	80	90	91
Space Operations	566	496	522	482
Institutional Support/Other	111	69	114	1,162
Total	**6,046**	**5,983**	**5,973**	**6,726**

*Beginning in FY 2002, Institutional Support is included in each Enterprise. FY 2002 reflects September Operating Plan.

grew, other Agency programs were affected. The sound cost projections and management controls implemented in FY 2002 will allow the Agency to make decisions with greater confidence.

Space Communications continued to provided reliable, high quality, cost-effective command, tracking, and telemetry data services between the ground facilities and flight mission vehicles at an annual cost of about half that of a decade ago.

In acquiring expendable launch vehicle launch services, we continued highly successful oversight that has resulted in 98 percent reliability. That is 3 percentage points above the predicted design reliability for these vehicles. In FY 2002, all five NASA-managed launches were successful. This avoided costs that would have accrued due to lost research results and the need for replacement spacecraft.

Aerospace Technology

NASA's aerospace technology research improves life here on Earth in many ways, including making air travel safer and more convenient while reducing air and noise pollution. Moreover, this work advances NASA's efforts to extend life beyond Earth by supporting development of better access to space. In FY 2002, aerospace technology efforts also helped enhance NASA's programs to find life beyond Earth by applying technology development to future space science programs.

Strategic Goal 1. Revolutionize Aviation—Enable the safe, environmentally friendly expansion of aviation

Strategic Objective 1. Increase Safety—Make a safe air transportation system even safer

Annual Performance Goal 2R1. Complete the interim progress assessment utilizing the technology products of the aviation safety program as well as the related aerospace base research and technology efforts and transfer to industry an icing CD-ROM, conduct at least one demonstration of an aviation safety-related subsystem, and develop at least two thirds of the planned models and simulations.

We met this annual performance goal by delivering a pilot training program, by demonstrating several safety-related subsystems, including the Aviation Weather Information Program's forward-looking turbulence detection system, and by completing the planned models and simulations. For this performance goal, we achieved a rating of green.

Indicator 1. Complete a general aviation pilot survey

Results. We developed two versions of the general aviation pilot questionnaire: one for fixed-wing aircraft and one for rotorcraft, both with emphasis on weather-related safety issues. We analyze and send data from the surveys to the air traffic management and air carrier decision-makers. Through the surveys, pilots can report and raise issues regarding the national air system, and air traffic management has the data to ensure that changes introduced to the system are producing expected improvements.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

The survey pool includes corporate pilots, flight instructors, and air medical operators. We receive about 670 completed surveys per month for a completion rate approaching 70 percent.

Indicator 2. Model high error probability contexts and solutions

Results. We completed the initial matching of modeling errors and results to full-mission simulations. We completed and evaluated a simulation plan. This work was not completed in FY 2002, but, as it is of importance to the goal, the work will be continued and is expected to be completed in FY 2003.

Data Quality. Mission performance data accurately reflect activities in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 3. Demonstrate loss of control and recovery models

Results. An enhanced control and recovery simulation characterizes aircraft behavior under adverse and upset conditions. The simulation incorporates data from static and dynamic wind-tunnel tests for large angles of attack and sideslip and mathematical models of adverse and upset conditions. The results of this research will improve aircrew training for upset recovery and simulations for accident investigations.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 4. Flight demonstrate forward-looking turbulence warning systems

Results. A research radar turbulence-warning system with real-time hazard estimation algorithms has demonstrated its promise to improve turbulence detection and hazard estimation. In 20 flights conducted from 2000 through 2002 and with 43 turbulence encounter files collected, the system showed a probability of detecting severe turbulence more than 30 seconds ahead of time at 81 percent and a nuisance alarm rate of 11 percent. We based our radar turbulence algorithms on current commercial radar detection instruments for transport aircraft so that they could be used to retrofit those radar systems.

NASA develops new international aviation weather information network

The international Aviation Weather Information Network (AWIN) provides critical information about potentially hazardous in-flight weather conditions. Before AWIN, pilots relied on preflight weather briefings and occasional in-flight pilot reports, but up to the minute forecasts in the cockpit were unavailable. NASA developed AWIN in partnership with the FAA, industry, and university researchers.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

We compared the turbulence-warning system data with true winds and loads, which were calculated from instruments readings taken when the aircraft reached the site of the predicted turbulence.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 5. Demonstrate a national aviation weather information network (AWIN) capability

Results. Through cooperative agreements with industrial partners, we demonstrated four graphical weather displays for transport and general-aviation aircraft: (1) Honeywell's Weather Information Network (with in-service evaluations by United Airlines) showed its ability to mitigate turbulence. (2) The Rockwell Enhanced Weather Radar system demonstrated the display of uplinked weather service data combined with onboard radar data on a graphical weather information system. (3) ARNAV Systems' Weather Hazard Information System for general-aviation aircraft showed the usability of its displays in both retrofit and new cockpit installations. (4) Honeywell's graphical weather information for general aviation demonstrated its beneficial effect on the pilot decision-making. For all of these technologies, we consulted with the developers during the design or testing phases and in some cases provided the research aircraft for the tests. Overall, our collaboration with industry allowed us to reach the target of demonstrating six graphical weather display technologies a year earlier than planned.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 6. Demonstrate a national AWIN data link capability

Results. Four digital communications technologies demonstrated in-flight the dissemination of graphical weather information to aircraft cockpit displays. Flight demonstrations included the following:

We helped flight test Honeywell's broadcast-only, VDL (very high frequency (VHF) data link) Mode 2 ground stations and airborne receivers in one of our general aviation research aircraft. We consulted with ARNAV Systems in evaluating its two-way VHF data link technologies. The FAA has selected both of these systems for its Flight Information Services Datalink policy. United Airlines' in-service evaluations of Honeywell's Weather Information Network transport system included the first approved use of true Internet Protocol to a Federal Aviation Regulation 121 flight deck via sky phone technology. The crew used a Skyphone, commonly found on commercial transport aircraft for passenger telephony, with a dial up modem to provide low-data-rate digital transfer of graphical weather information. As mentioned in the results for indicator 5, because of these collaborations with industry we reached our demonstration goal a year earlier than planned.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 7. Validate structural crash analysis tools

Results. A NASA Technical Memorandum entitled "Best Practices in Crash Modeling and Simulation" describes

experiences in developing dynamic finite-element crash models, model execution, analytical predictions, test-data analysis, filtering procedures, and test-analysis correlation. This tool enables first-time users to avoid common pitfalls in crash modeling. From the best practices, the authors generated models with dynamic finite-element codes (enhanced by the vendor for better crash simulation). The report includes examples of work that has been reviewed, evaluated, and presented to other Government agencies, including the FAA and Army, and private industry. The authors used both qualitative and quantitative test-analysis correlations to evaluate the crash models. The efficiencies documented could reduce costs for users 10 to 25 percent.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 8. Complete an interim integrated program assessment

Results. Our most recent assessment of the Aviation Safety Program shows it to be on track for developing technologies that, when fully implemented, can reduce the fatal accident rate. During the assessment, we determined the technical development and implementation risk for synthetic-vision systems, weather accident prevention, system-wide accident prevention, and accident mitigation products. We also determined the safety benefit, using risk as a metric, for selected synthetic vision and system-wide accident prevention products. The assessment showed the technical risk to be significantly lower today than it was during a previous assessment and that implementation risk has progressed.

Data Quality. Mission performance data accurately reflect achievements in FY 2002. Technical development risk assessment considered technology advancement, status, complexity, and dependencies. Implementation risk considered certification impacts, dependencies, market penetration, and market impacts.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 9. Develop and distribute a CD-ROM self-paced icing training module for pilots

Results. We developed a self-paced, computer-based training program that presents student and professional pilots with operational information and tools to detect and avoid ice and minimize exposure to it. The training program describes the effects of icing on aircraft performance, control upsets (wing and tail stalls), and recovery procedures. Ice-accretion images, pilot testimonials, animation, case studies, and interactive demonstrations supplement the information. Interactive exercises help users test their understanding of the key points. This training program complements the earlier instructor-led icing training released in videotape in 2000. NASA collaborated with the FAA, Air Line Pilots Association, and University of Oregon for this production. Organizations, including U.S. and European airline operators, Cessna Aircraft Co., Transport Canada, United Express, Ohio Civil Air Patrol, and the U.S. Army Safety Center, received the training program. Most not only praise the quality of the training, but also have incorporated it into their training programs.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

The basis for the information contained in the training program is flight and wind-tunnel studies of the effects of ice accretion on lifting surfaces, NASA-developed computer codes that predict aircraft response to ice accretion, and NASA pilot experience. For more information about the icing research program, see http://icebox.grc.nasa.gov/.

Indicator 10. Develop a methodology for the design and verification of task driven human automation systems

Results. Researchers developed a mathematical procedure for verifying the correctness of the interfaces (displays, etc.) between humans and automation products on the flight deck of an aircraft. They focused on whether information provided in cockpit displays, user manuals, and training was adequate to perform tasks. Researchers developed a systematic methodology and algorithm for generating displays. Designers of aviation and air-traffic control systems can use the methodology to ensure that human-automation interfaces are free of design errors.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

For more information about the methodology, see "On Abstractions and Simplifications in the Design of Human-Automation Interfaces," NASA/TM-2002-21397.

Indicator 11. Complete validation of new perceptual measurement tools for evaluating display effectiveness as it supports human performance

Results. Researchers developed and validated six new tools for studying the sensory and motor actions of a human operator (pilot or controller) when interacting with the displays and controls of aviation and air-traffic-control

systems. A new experimental methodology and performance metric called oculometrics uses eye movement to estimate an operator's perceptual and cognitive state. Oculometrics can be used to monitor air-traffic-control performance and to train general-aviation pilots in see-and-avoid scenarios. A software-based, real-time virtual audio rendering system called Sound Lab, allows researchers to study spatial hearing in virtual simulations. A text readability metric predicts the effect of a textured background on the readability of transparent text. This tool is already improving new displays using text and symbols overlaid on maps and images with textured backgrounds. Metrics and models of range and closure perception predict human performance during tasks that require depth perception and control. A computational model, designed for use in a virtual environment (for example, an airport tower) as experienced through a head-mounted display, predicts motion artifacts. A technique anticipates head motion to reduce latency (the time it takes the computer to display the correct image after it detects head motion) in virtual environment applications.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

For more information about psychological and physiological stressors and factors, see http://vision.arc.nasa.gov/PPSF/.

Indicator 12. Generate initial model for flight crew scheduling assistant based on sleep and circadian cycles

Results. Researchers developed a bio-mathematical model and algorithm to predict flight crew alertness and performance during commercial long-haul flights. Researchers gathered sleep and circadian (or 24-hour) rhythm variables and light measurements of pilots at various times throughout long-haul flights. The model is a first step in developing a software-based program that will help commercial airlines predict the effect of acute sleep loss, cumulative sleep loss, and circadian rhythm disruption on flight crew behavior, performance, and alertness. Commercial airlines will be able to use the Scheduling Assistant software to plan flight crew schedules and to help minimize fatigue-related problems during long haul flights.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Researchers assured model quality by integrating data collected over many years in tightly controlled laboratory experiments and field studies conducted by leading researchers in the fatigue and modeling fields.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

For more information about NASA's research on fatigue countermeasures, see http://olias.arc.nasa.gov/zteam/.

Indicator 13. Demonstrate prototype technologies for an aviation safety information system

Results. No research was conducted to support this indicator. As planned in FY 2000, this indicator was supported by activities in the information technology program. As a result of FY 2001 replanning activities to integrate all of the information technology research into the Computing, Information, and Communications Technology Program (which focuses its efforts on the pioneer technology innovation goal), this work was deemed not of significant priority to warrant its continuation.

Data Quality. Not applicable.

Data Sources. Not applicable.

Indicator 14. Assess the electromagnetic impact on critical flight control hardware through physics-based modeling of the electromagnetic fields

Results. A three-dimensional, physics-based computational electromagnetic code provides an accurate, safe, and cost-effective method for assessing the effect of lightning and other electromagnetic interference on aircraft structures and avionics systems. The code is a hybrid finite-element/finite-difference transient code from the Parallel Scientific Computing Institute at Uppsala University in Uppsala, Sweden, and the Royal Institute of Technology in Stockholm, Sweden. The code solved the problem, a structured, finite-difference Cartesian grid with 1 billion cells constructed for a Saab 2000 aircraft, on a massively parallel computer cluster at NASA Langley.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 15. Develop concepts for advanced sensory materials and for embedding sensors into aerospace structural materials

Results. We developed prototype inductor piezoelectric sensors that can be embedded in structural materials and a new concept for coupling to embedded optical fiber sensors. Compared with traditional surface-mounted sensors, embedded sensors offer numerous advantages. These include protection of the sensors from damage, integration of the sensors during manufacture rather than as costly add-ons, and avoidance of material surface modification.

In addition, several concepts for embedding integral vehicle health monitoring sensors into aerospace structural materials have been developed, and some preliminary tests have been performed. If successful, these concepts will

enable the development of embedded sensors in future aerospace vehicles.

The novel fiber-optic concept results in significant reduction in complexity and 50-percent cost reduction for embedding sensor systems into aerospace structural materials. The concept also has the potential to benefit aircraft safety by reducing catastrophic failure of the airframe.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Strategic Goal 2. Advance Space Transportation—Create a safe, affordable highway through the air and into space

Strategic Objective 1. Mission Safety—Radically improve the safety and reliability of space launch systems

Annual Performance Goal 2R6. NASA's investments emphasize thorough mission needs development, requirements definition, and risk-reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk-reduction and architecture reviews to support design and demonstration decisions.

We achieved a rating of green for this annual performance goal by successfully completing the risk-reduction and architecture reviews and the using those reviews to identify the most viable architectures and technology investments. Although the Space Launch Initiative treats safety and cost as separate elements, the risk-reduction review covered both. Therefore, the results for indicators 1 and 2 of annual performance goals 2R6 and 2R7 are the same.

Indicator 1. Conduct risk-reduction review

Results. The Space Launch Initiative regularly conducts risk-reduction reviews to determine if the program is ready to proceed to the next development phase. We reviewed every program element, including all technology projects and the Architecture Definition Office. All reviews were completed in March 2002. Ongoing monthly and quarterly reviews monitor the program's overall state of health. The monitoring allows the program manager to redirect or even cancel project activities as needed to optimize performance.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

The performance data regularly collected and assessed directly correlates to program work breakdown structure elements, which, in turn, correlate to specific program and project goals. These data include resource-loaded logic schedules, cost performance reports (earned value management), and financial reports. Project offices assess monthly data using analysis tools for earned-value management. As a crosscheck, the program office independently assesses these data and may adjust priorities, reallocate resources, or take other appropriate action to ensure that risk-reduction investment is sound. The program developed a risk and cost plan based on methodologies and tools to manage the technology portfolio actively to support a full-scale development decision.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers. For further information about our activities, see http://sli.msfc.nasa.gov/.

Indicator 2. Conduct interim architecture review to establish the candidate space transportation architectures

Results. The Space Launch Initiative has completed its first milestone review, resulting in a reduced number of candidates for the second-generation reusable space transportation system. The initial architecture technology review analyzed and evaluated competing architectures and technologies against NASA and commercial mission requirements.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers. For more information about the reviews, see the initial architecture technical review press release at http://www1.msfc.nasa.gov/NEWSROOM/news/releases/2002/02-108.html.

Strategic Objective 2. Mission Affordability—Create an affordable highway to space

Annual Performance Goal 2R7. NASA's investments emphasize thorough mission needs development, requirements definition, and risk-reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk-reduction and architecture reviews and initial hardware demonstrations to support design and demonstration decisions.

We met this annual performance goal by successfully completing the risk-reduction and architecture reviews and by the using these reviews to identify the most viable architectures and technology investments. We achieved a rating of green for this performance goal. Although the Strategic Launch Initiative treats safety and cost as separate elements, the risk-reduction review covered both. Therefore, the results for indicators 1 and 2 of annual performance goals 2R6 and 2R7 are the same.

Indicator 1. Conduct risk-reduction review

Results. See annual performance goal 2R6, indicator 1.

Data Quality. See annual performance goal 2R6, indicator 1.

Data Sources. See annual performance goal 2R6, indicator 1.

Indicator 2. Conduct interim architecture review to establish the candidate space transportation architectures

Results. See annual performance goal 2R6, indicator 1.

In addition, the program added RP (hydrocarbon) propulsion investments, guidance for a study of booster jet-back propulsion, realigned the airframe project to accelerate metallic tank development, and reduced the avionics investments.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 3. Demonstrate advanced adhesives for nonautoclave composite processing

Results. A new class of high-flow adhesives, phenylethynyl terminated imides, which can be processed using only a vacuum bag and oven, has demonstrated excellent adhesive strengths. The tensile-shear strength for titanium-to-titanium bonds was 6,200 pounds per square inch at 350 degrees Fahrenheit and for composite-to-composite bonds, 2,300 pounds per square inch at the same temperature. The goal of this research is to produce a strong, high-strength adhesive that does not require the use of an autoclave (or high-pressure furnace). The advantage of the nonautoclave processing of large pieces (such as a cyrotank) is that they can be processed at much lower manufacturing cost (that is, space, time, equipment, materials, labor, etc.) yet provide comparable performance and reusability.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 4. Complete systems requirements review on rocket-based combined-cycle demonstrator engine

Results. The systems requirements review board for the rocket-based combined cycle demonstrator engine identified 135 discrepancies and proposed solutions at its initial meeting. The board met in September for final review and disposition of all discrepancies. The board also directed the project to conduct another review, when work resumes on the flight-test engine, to consider data generated by the ground test engine project. With the completion of this activity, the project will proceed with ground test engine preliminary design.

Data Quality. Mission performance data accurately reflect achievements in FY 2002. The review board's database contains the discrepancy item, the proposed solution of the reviewer, developer comments, and the disposition of the item.

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program or project managers. The project office maintains the board minutes and tracks the closure of all discrepancies and action items.

Indicator 5. Demonstrate reaction transfer molded polymer matrix composite with 550 degrees Fahrenheit use temperature

Results. This effort was deferred as a result of a reprioritization that required work to be performed in other program areas. Polymer matrix composite development is important to the goal, however, and we expect to complete this indicator in FY 2003.

Data Quality. Not applicable.

Data Sources. Not applicable.

Strategies and Resources to Achieve Goals

The aerospace technology goals to key activities table shows the relationships among strategic goals, strategic objectives, and key activities. In FY 2002, the Aerospace Research and Technology Program consisted of five basic research programs and six focused programs. The basic research programs develop advanced concepts, physics-based understanding of aerospace phenomena, validated models and design tools, design and manufacturing aids and processes, and aerospace and multidiscipline technologies. These programs are not specific to any mission, user, vehicle, or other application. By contrast, the focused programs develop and adapt basic research products for mission and other applications to the point that they are ready for transfer to a user.

The five basic research programs are:

The Computing, Information, and Communications Technologies Program develops computing technologies for mission planning and scheduling; aerospace platforms; avionics software; deep-space mission control and monitoring; and space-communications network development and data analysis. A number of previously independent budget line items, including information technology base, design for safety, bio-nanotechnology, aerospace autonomous operations, and intelligent systems, are now within this program.

The Vehicle Systems Technology Program develops aeronautics, space transportation, spacecraft, and science sensing systems technologies. Emphasis areas are conceptual

design, aerodynamic and structural design and development, smart materials and structures, flight crew station design, systems design and testing, and third-generation space transportation.

Aerospace Propulsion and Power Technology Program research focuses on maintaining U.S. superiority in engine technology and ensuring the long-term environmental compatibility, safety, and efficiency of propulsion systems. It addresses critical propulsion technology needs, including advances in conventional aeropropulsion and unconventional propulsion technologies such as fuel-cell-based propulsion, high-temperature nanomaterials, and self-adapting, efficient engine components.

The Flight Research Program conducts NASA's atmospheric flight research. The program promotes technology innovation, discovery of new phenomena, and the development of new aerospace concepts. The program flight-tests experimental aircraft and tools to validate them a in a realistic environment.

The Space Transfer and Launch Technology Program develops and ground-tests technologies to meet the requirements of future launch systems: lower cost and higher reliability and performance. The program will bring these technologies to a point of readiness levels at which NASA missions and industry can adopt them.

The six focused programs are:

The Aviation System Capacity Program supports the strategic objective of "while maintaining safety, double the aviation system throughput in all weather conditions within 10 years, and triple it within 25 years." The program develops technology that will enable safe increases in airport capacity through modernization, air traffic management improvements, and new vehicles that can reduce congestion.

The Aviation Safety Program works to improve aviation safety as measured by aircraft accident and fatality accidents involving weather, controlled flight into terrain, human-error, and mechanical or software malfunctions. The program emphasizes not only accident-rate reduction, but also reducing the number of injuries and fatalities in accidents that do occur. The program works in close partnership with the FAA to implement research results and collaborates with the DOD and other Government agencies.

The Ultra-Efficient Engine Technology Program develops engine technologies to enable a new generation of high-performance, operationally efficient arates. Research and technology development addresses and economical, reliable, and environmentally compatible U.S. aircraft. The focus is on propulsion components and high-temperature engine materials.

The Small Aircraft Transportation System Program develops new operating capabilities for small aircraft. One such capability is a precision guidance system that will work for virtually any small airport "touchdown zone." The objective is to facilitate use of underutilized airports (such as those without control towers) and underutilized airspace (such as the low-altitude, nonradar airspace below 6,000 feet). Such technologies could create alternatives for addressing the nation's unmet transportation demand, which reveals itself in increased highway congestion and airport delays.

The Quiet Aircraft Technology Program is developing technologies to further reduce noise around airports. The program addresses both mechanical and operations techniques to reduce noise. Achieving the noise reduction goal will facilitate the projected growth in air travel while offering the potential to reduce the associated noise impact.

The Second Generation Returnable Launch Vehicle Program is developing technologies to reduce the technical, programmatic, and business risks of developing a safe, reliable, and affordable second generation returnable launch vehicle. The program will invest in design and development leading to at least two vehicle options for a mid-decade competition.

The aerospace technology resource estimates table gives budget authority figures for FY 1999 to FY 2002.

Cost-Performance Relationship

In achieving the strategic goals shown in the mapping aerospace technology goals to key activities table, during FY 2002, NASA incurred research and development expenses for the programs as follows. All of the resources went to research and development, and of this total more than 99 percent was spent on applied research. Less than half of 1 percent was spent on development, and no resources were spent on basic research. For a description of the three research categories and a summary of NASA's total research and development expenses, see the "Required Supplementary Stewardship Information—Stewardship Investments: Research and Development" schedule in Part III of this report.

Budget-Performance Relationship

In FY 2002, the aerospace technology programs were separated into two groups: focused technology and base research and technology. The base research and technology programs explore technology concepts and each program supports a number of goals and strategic objectives. In FY 2002, the aerospace technology effort had $2.549 billion budgeted to support the goals and objectives. The base research and technology programs (Aerospace Vehicle Systems Technology, Aerospace Propulsion and Power, Flight Research, and Rotorcraft) accounted for 14 percent of the budget to support all of the goals and objectives through concept exploration. The revolutionize aviation goal accounted for 10 percent of the budget as supported by the Aviation System Capacity, Aviation Safety, Ultra-Efficient Engine Technology, Small Aircraft Transportation System, and Quiet Aircraft

Mapping Goals and Objectives to Key Aerospace Technology Activities

Strategic Goal	Strategic Objective	Key Activity
Revolutionize Aviation—Enable the safe, environmentally friendly expansion of aviation	Increase Safety—Make a safe air transportation system even safer	Aviation Safety Technology; Computing, Information, and Communication Technology; Propulsion and Power; Vehicle Systems Technology
	Reduce Emissions—Protect local air quality and our global climate	Ultra-Efficient Engine Technology, Propulsion and Power, Vehicle Systems Technology
	Reduce Noise—Reduce aircraft noise to benefit airport neighbors, the aviation industry, and travelers	Quiet Aircraft Technology, Propulsion and Power, Vehicle Systems Technology
	Increase Capacity—Enable the movement of more air passengers with fewer delays	Aviation System Capacity; Computing, Information, and Communication Technology; Vehicle Systems Technology
	Increase Mobility—Enable people to travel faster and farther, anywhere, anytime	Small Aircraft Transportation System, Vehicle Systems Technology
Advance Space Transportation—Create a safe, affordable highway through the air and into space	Mission Safety—Radically improve the safety and reliability of space launch systems	Second Generation Returnable Launch Vehicle; Computing, Information, and Communication Technology; Space Transfer and Launch Technology
	Mission Affordability—Create an affordable highway to space	Second Generation Returnable Launch Vehicle I; Computing, Information, and Communication Technology; Propulsion and Power; Vehicle Systems Technology; Space Transfer and Launch Technology
	Mission Reach—Extend our reach in space with faster travel times	Propulsion and Power, Space Transfer and Launch Technology
Pioneer Technology Innovation—Enable a revolution in aerospace systems	Engineering Innovation—Enable rapid, high-confidence, and cost efficient design of revolutionary systems	Computing, Information, and Communication Technology; Flight Research; Propulsion and Power; Vehicle Systems Technology; Space Transfer and Launch Technology
	Technology Innovation—Enable fundamentally new aerospace system capabilities and missions	Computing, Information, and Communication Technology; Propulsion and Power; Vehicle Systems Technology; Space Transfer and Launch Technology
Commercialize Technology—Extend the commercial application of NASA technology for economic benefit and improved quality of life	Commercialization—Facilitate the greatest practical utilization of NASA know-how and physical assets by U.S. industry	Aviation Safety Technology; Aviation System Capacity; Ultra-Efficient Engine Technology; Small Aircraft Transportation System; Quiet Aircraft Technology; Second Generation Returnable Launch Vehicle; Computing, Information, and Communication Technology; Flight Research; Propulsion and Power; Vehicle Systems Technology; Space Transfer and Launch Technology
Space Transportation Management—Provide commercial industry with the opportunity to meet NASA's future launch needs, including human access to space, with new launch vehicles that promise to dramatically reduce cost and improve safety and reliability. (Supports all objectives under the Advance Space Transportation Goal)	Utilize NASA's Space Transportation Council in combination with an External Independent Review Team to assure Agency-level integration of near- and far-term space transportation investments	Second Generation Returnable Launch Vehicle

Technology Programs. The advanced space transportation goal accounted for 21 percent of the budget and was supported by the Second Generation Reusable Launch Vehicle and Space Transfer and Launch Technology Programs.

In FY 2002, the aerospace technology effort assessed its progress to the goals by rigorous evaluation of the program deliverables against the program plans. For each focused program, a program commitment agreement specified the performance and what the program would demonstrate based on an established schedule and financial resources. The progress of each program was monitored quarterly by an Agency status review and by a yearly independent implementation review. These reviews did

Resource Estimates of Key Aerospace Technology Activities

Key Activity	Budget Authority (in $ Millions)			
	FY 1999	FY 2000	FY 2001	FY 2002*
Aviation System Capacity	54	63	68	94
Aviation Safety	21	64	71	86
Ultra-Efficient Engine Technology	0	68	48	50
Small Aircraft Transportation System	0	0	9	16
Quiet Aircraft Technology	0	18	20	20
Second Generation Reusable Launch Vehicle	0	0	272	465
Aerospace Vehicle Systems Technology	138	149	152	157
Aerospace Propulsion and Power	75	78	85	95
Computing, Information, and Communication	67	74	118	195
Space Transfer and Launch Technology	64	95	77	70
Space Base NASA Research Announcement	0	0	40	40
Flight Research	64	71	83	82
Rotorcraft	27	27	32	13
Institutional Support/Other	829	418	329	1,166
Total	**1,339**	**1,125**	**1,404**	**2,549**

*Beginning in FY 2002, Institutional Support is included in each Enterprise. FY 2002 reflects September Operating Plan.

not identify any management issues that would jeopardize the deliverables within the established schedule and cost. The FY 2002 activities and technologies that were necessary to demonstrate progress toward the strategic goals were accomplished within the allocated budget.

Data Verification and Validation

NASA is committed to ensuring that its performance data are reliable and verifiable. Data credibility is crucial to our efforts to manage for results and to be accountable. Therefore, we evaluate our performance in developing and providing products and services at all levels, from the Agency level to individual program and project levels. Each level is responsible for monitoring and reporting results. Whenever performance fails to meet plan, we identify strategies for reengineering and continual improvement. In cases where performance poses a major concern, we conduct special evaluations and institute targeted mitigation programs. We then carefully examine the results of such programs to guide planning and budget decisions.

NASA also relies on external reviews. These include an extensive peer-review process in which panels of outside scientific experts ensure that science research proposals are selected strictly on the merits of the research plan and expected results. We rely on a broad, diverse system of advisory committees established under the Federal Advisory Committee Act, including the NASA Advisory Council and the Aerospace Safety Advisory Panel and their subcommittees. Hundreds of science, engineering, and business experts on these committees provide external input on management, programs, strategic plans, and performance. Advisory committees explicitly review and evaluate performance data, integrating quantitative output measures and taking into account considerations of safety, quality, results, and risk. NASA presented much of the results described in this report to these advisory committees for review. NASA also relies on periodic evaluations from specially convened panels of experts and from external organizations such as the National Academy of Sciences and the General Accounting Office (GAO). An independent accounting firm, PricewaterhouseCoopers, audited the financial statements. They also obtained an understanding of the design of significant internal controls surrounding the performance measures highlighted in the FY 2002 report. Their findings appear in Part III.

Actions Planned to Achieve Key Unmet Goals

Despite a year of many successes, two events adversely affected our ability to achieve our goals. One was the loss of the CONTOUR mission, the other the decision not to fly all of the scheduled Shuttle missions. Fortunately, we will be able to recover from both of these. The Stardust mission and the Rosetta mission that we are conducting jointly with the European Space Agency will help provide much of the information we had expected to achieve from CONTOUR. In addition, in the future we hope to conduct other missions to other comets and primitive bodies. In FY 2003, NASA will fly three Shuttle missions that we delayed in FY 2002 because of safety concerns about the fuel flow liner.

Looking Forward

As at every Federal agency, in planning how to achieve our mission, we at NASA must take into account what we think will happen in the future. Some future events and conditions will advance our efforts; others may work against us. Some events we can control in whole or in part; others are independent of our actions. Some future events we see already from a distance and so we plan for them; others will be a complete surprise. To persevere despite them, we need a flexible organization and hardy plans that are robust across a range of possible futures.

Adept planning and program management takes all of these considerations into account. This entails spotting trends and assessing their potential effects, preparing for likely risks and opportunities, and keeping the organization agile and perceptive enough to meet the future in whatever form it takes. NASA is working to ensure our ability to do this. Besides building in organizational flexibility, we are preparing for areas where future risks and challenges are certain. The most pressing of these in the near term are human capital, obsolescence of plant and equipment, security, and launch capability.

In the human capital area, two factors are especially problematic. First, much of today's NASA workforce will be eligible to retire in 10 years. This represents a major loss of institutional knowledge and experience. Our ability to replace these employees with a workforce of a similar caliber is not guaranteed. In recent years, the number of U.S. undergraduate and graduate students in science and engineering has declined. Further, many graduates in these fields come from other countries and return home after obtaining their U.S. degrees. At the same time, the private sector competes energetically and effectively for science and technology graduates; in many areas, the typical government compensation package fails to match what the private sector offers.

This problem, however, is not unique to NASA; human capital has been named one of the President's Management Agenda initiatives. An effort is ongoing Government-wide to increase human capital flexibilities and add a range of financial and non-financial hiring incentives. NASA's activities in this area and in the areas of knowledge sharing, mentoring, and leadership development are innovative and wide-ranging. For a detailed discussion of our activities in this area, please see the President's Management Agenda discussion at the end of Part I.

In addition, while NASA has always conducted outreach activities to inspire students to study science, mathematics, and technology, we are now embracing this responsibility even more whole-heartedly. In FY 2002, NASA initiated creation of an Education Enterprise to coordinate and lead our education initiatives. When asked what they

NASA recruits Mars explorers

Newspapers nationwide made the first discoveries from NASA's 2001 Mars Odyssey mission front-page news: lots of water ice found on the planet. Now students watching public television and NASA-TV and connecting over the Web can interact with some of the researchers who made headlines. They can also explore Mars for themselves, through the amazing images sent back to Earth.

Live from Mars! originates from the Mars Student Imaging Facility, at Arizona State University. Supported by NASA's Jet Propulsion Laboratory, it opened February 22, just days after the first Odyssey science images arrived. Here, Cindy Wurmnest, a sixth grade teacher at Danvers Elementary School and group faculty sponsor is interviewed for a broadcast.

want to be when they grow up, children still frequently say, "Astronaut!" Through our education and human capital initiatives, we intend to both foster this youthful interest in the adventure and mystery of space and to create an environment that will welcome our best students when they are ready to choose a career.

Another significant challenge is security. Since the September 11 terrorist attacks, the need for adequate security has become even more pressing. This encompasses the physical security of NASA's employees and installations; information technology security; and protection of sensitive data such as export-controlled technical information, industrial proprietary information, and classified information. All three areas were among the major management challenges and high-risk areas noted by recent OIG and GAO reports. NASA addressed each of these in FY 2002. For a detailed discussion, see the Major Management Challenges section, particularly the segments on Information Technology Security, Security of Facilities and Technology, and International Agreements.

Obsolescence of NASA's infrastructure remains a major and growing challenge. Much of our infrastructure was built in the 1960s during the ramp-up of the Apollo program. Other facilities are even older, dating from World War II. All of these facilities require intensive maintenance, which is complicated by the frequent unavailability of repair parts. We must often alter buildings to meet changing mission and environmental requirements.

Our facilities management strategy in the face of this challenge is threefold. First, we are reducing our real property and physical plant holdings. For example, we have established a central demolition fund to demolish aged facilities that we no longer need, and we are preparing to conduct a thorough Agency-wide review of our holdings to identify further opportunities for reductions. Second, we are putting underutilized property to work for the Agency, leveraging its value through third-party uses and initiatives such as enhanced-use leasing, and preparing a real property business plan. Third, we are working to sustain the real property that we still need. For NASA to remain viable, we must repair critical facilities and maintain them at adequate standards. We are continuing to reduce maintenance costs through programs such as reliability-centered maintenance, new technology, and sustainable designs, and pursuing innovative solutions such as third-party financing.

Another area of near-term concern is launch vehicles. The OIG raised issues about the Shuttle in its reports. These are addressed in the discussion of major management challenges at the end of Part I. In addition to Shuttle issues, however, there is concern about the continued availability of small- and medium-class launch vehicles needed for many of our space science and Earth science payloads. More than 80 percent of launches of NASA's scientific and Earth-observing spacecraft in the next 10 years are planned for small (Pegasus class) or medium (Delta II class) launch vehicles. Current launch industry trends show that the market for this class of service is flat, with NASA projected to become the dominant user. Last year's report noted that it was unclear whether the vehicles would continue to be available to meet our needs. However, as of the end of FY 2002, NASA was making progress toward awarding a block buy of launch services on 19 Delta II vehicles and expected to award this contract by the end of the calendar year.

This purchase will ensure that we have launch capability for these missions through the end of the decade. We are also working with our DOD counterparts to coordinate launch opportunities for our smallest payloads, either as the only payload on existing small launchers and refurbished intercontinental ballistic missiles or as secondary payloads sharing larger vehicles.

NASA encourages recycling

What would it cost NASA to dismantle two 107-ton turbine engine drivers and 35 tons of associated hardware? Recently, a company removed the equipment free of charge, saving NASA more than $350,000 in demolition and restoration costs. After years of searching, NASA's Glenn Research Center found, through an intermediary, a company willing to pay the removal and delivery costs. The photo shows the excavating company's 650-ton crane hoisting the equipment onto a trailer. The drivers, which once helped NASA researchers test designs for jet engines, had not been used since 1984.

Analysis of Financial Statements

NASA's financial statements were prepared to report the Agency's financial position and results of Agency operations. The Chief Financial Officer's Act of 1990 requires that agencies prepare financial statements to be audited in accordance with Government Auditing Standards. While the financial statements were prepared from NASA books and records in accordance with formats prescribed by Office of Management and Budget (OMB), these statements 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.

NASA received a disclaimer of audit opinion on its FY 2001 financial statements. Federal Accounting Standards Advisory Board No. 21, Reporting of Errors and Changes in Accounting Principles ("FASAB No. 21"), requires that errors discovered in previously issued financial statements be corrected by restating the affected period. If the error occurred prior to the earliest period presented, the cumulative effect should be reported as a prior period adjustment. NASA detected certain errors during 2002 that occurred in prior years and recorded those errors as if they had occurred in FY 2001. NASA was not able to determine what portion of those errors related to years prior to FY 2001 and, as a result, should have been recorded as prior period adjustments to Property, Plant and Equipment, Materials and Cumulative Results of Operations as of the beginning of FY 2001. Instead, NASA has restated its FY 2001 financial statements and has recorded in its balance sheet and statement of net cost ($2.8 billion) in adjustments relating to corrections of errors caused primarily by the lack of internal controls surrounding Contractor-Held Property, Plant and Equipment and Materials and NASA-Owned Assets-in-Space and Work In Process. While this action did not remove the disclaimer of audit opinion associated with FY 2001 statements, it provided FY 2002 beginning balances so that NASA's independent public accountant was able to express an unqualified audit opinion on the FY 2002 financial statements.

ASSETS, LIABILITIES AND CUMULATIVE RESULTS OF OPERATIONS

The Consolidated Balance Sheet reflects total assets of $44.1 billion and liabilities of $4.4 billion for FY 2002. Unfunded liabilities reported in the statements cannot be liquidated without legislation that provides resources to do so. About 79 percent of the assets are Property, Plant, and Equipment (PP&E), with a net book value of $35.0 billion. PP&E is property located at NASA installations, primarily the Centers, in space, and in the custody of contractors. Almost 69 percent of PP&E consists of assets held by NASA, while the remaining 31 percent represents property in the custody of contractors. The net book value of Assets in Space, various spacecraft operating above the atmosphere, constitutes $17.0 billion, or 71 percent of NASA-owned and NASA-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 $35.8 billion. The Agency's $39.7 billion net position includes $3.9 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 is designed to show separately the components of net cost of NASA's operations for the period. In FY 2002, NASA implemented our mission through five strategic Enterprises. Their total net costs in FY 2002 were: Human Exploration and Development of Space, $6.3 billion; Space Science, $2.8 billion; Earth Science, $1.5 billion; Biological and Physical Research, $720 million; and Aerospace Technology, $2.8 billion. Net cost is the amount of money NASA spent to carry out programs funded by Congressional appropriations.

Systems, Controls, and Legal Compliance

NASA has a variety of management systems in place. We use the Corrective Action Tracking System (CATS) II to track, complete, and close all recommended actions that result both from audits and from the major management reviews described below. This automated system gives us a current, clear picture of the state of our management actions and controls. In addition, the NASA Online Directives Information System (NODIS), an electronic document generation system and library containing all of the Agency's policies, procedures, and guidelines, provides official information for overall governance and control of Agency operations. This system is accessible to all employees and is keyword-searchable. These two automated systems work together to provide information throughout NASA on the status of key management actions.

We also have strong management controls. The Internal Control Council meets quarterly to discuss material weaknesses and major management challenges facing the

Agency. The Council then agrees on corrective actions for these problems and tracks them through to completion.

Signaling our committed approach to management controls, the highest levels of NASA senior management serve on this Council and on the many other Agency boards and councils that contribute to internal management controls. External auditors from the OIG and the GAO make recommendations to the Agency on a continuous basis, and we monitor in detail our activities in responding to these recommendations.

The corrective actions that senior management has implemented and assessed have significantly improved our internal controls. Our goal is to put in place reasonable controls, continually examine recommendations for their improvement, make sound determinations on corrective actions, and verify and validate the results. This commitment to accountability is evidenced by many control improvements and significant management initiatives taken by NASA leadership in response to law, the President's Management Agenda, GAO standards and audits, OMB guidance, OIG recommendations, and collaborative efforts to make the vision of "One NASA" a reality. A detailed description of examples of these actions is included in the final section of Part I of this report, Additional Key Management Information, particularly the section on management challenges and high-risk areas.

With regard to legal compliance with the Federal Managers' Financial Integrity Act, NASA is in full compliance. The Statement of Assurance is included in the Message from the Administrator that begins this report. Further information on NASA's compliance with the act is in the following section, Summary of Integrity Act Material Weaknesses and Non-Conformances.

Integrity Act Material Weaknesses and Non-Conformances

FEDERAL MANAGERS' FINANCIAL INTEGRITY ACT

The Federal Managers' Financial Integrity Act requires agencies to provide an Annual Statement of Assurance regarding management controls and financial systems. In FY 2002, NASA strengthened the Agency's overall management controls and reduced the single material weakness identified in FY 2001, International Space Station management, to an internally tracked significant area of management concern. Independent reviews and intense internal scrutiny by the Internal Control Council and the Station management team led to this decision to downgrade the material weakness to a control deficiency. Based on the recommendations of internal and external experts, NASA developed a corrective action plan and the Station management team completed corrective actions in accordance with it. NASA has tracked corrective actions on this issue internally and the Council will continue aggressive quarterly tracking. Our corrective actions were also externally assessed.

The 2002 Annual Decision Meeting of the Council included a variety of decision-making process changes and reforms for 2002 and beyond. In last year's meeting, NASA elevated the Station from a second-tier significant area of management concern to a first-tier material weakness. In the past, NASA reported both material weaknesses and significant areas of management concern in our annual accountability reports. This year, the Council chair initiated a more accurate implementation of the Integrity Act report, identifying only new material weaknesses and providing the status of corrective actions to reduce or close existing material weaknesses.

Significant areas of management concern described in previous years will no longer be reported externally but will be tracked and reported internally as prescribed by "Management Accountability and Control" (OMB Circular A-123). NASA's 2003 reform initiatives include working with the OIG to clarify and define current applicability of the term "material weakness" and renaming and redefining the term "significant area of management concern." This change also reflects NASA's responsiveness to reducing the Government's reporting burden per the Reports Consolidation Act and especially the President's Management Agenda message: "To reform government, we must rethink government." However, while NASA management has elected not to report at a level below material weakness externally, the OIG may continue its practice of reporting on additional management challenges and weaknesses, and has provided a new report, which is included in Part III. NASA's FY 2002 efforts to address issues listed in previous reports are discussed in the final section of Part I of this report.

Improving and maintaining management controls in response to GAO and the OIG audits requires continued aggressive oversight by the Council, internal reviews by Agency managers, and other evaluations such as the continual progress reports that the International Space Station management team provided to the OMB throughout FY 2002. We are aggressively correcting all management problems reported in the FY 2001 NASA Accountability Report. Among the major corrective actions we completed in FY 2002 on previously reported significant areas of management concern are Financial Management, Information Technology Security, Decommissioning of the Plum Brook Reactor Facility, the National Environmental Policy Act, and Cost Estimating. We will continue to implement and track corrective actions by holding regular progress meetings, systematically assessing results of corrective actions, and obtaining validated evidence that we have achieved the intended control results.

MATERIAL WEAKNESS

NASA has inadequate management controls for the financial reporting of property, plant, and equipment, and materials including Assets-in-Space, contractor-held property, spare parts and assets under fabrication. Regarding Assets-in-Space, various costs were not consistently capitalized in the period incurred. For contractor-held property reported on the required annual NASA Form (NF) 1018, "NASA Property in the Custody of Contractors," some contractors incorrectly reported the value or classification of NASA-owned property in their possession. These errors resulted in erroneous reporting of billions of dollars of assets and required reclassification of assets between depreciable and non-depreciable.

Working with NASA's auditors (the OIG and the independent public accountant with whom they have contracted) and various NASA contractors, we were able to revalue and reclassify these assets for NASA's FY 2002 financial statement presentation. However, because of the multitude of property, plant, and equipment, and materials reporting weaknesses including contractor-reported errors, the independent public accountant is reporting this condition as a repeat material weakness on our FY 2002 financial statements. To remedy this, we plan to improve our overall guidance on property, plant, and equipment, and materials. We also plan to increase our training to contractors on NF1018 reporting.

MATERIAL WEAKNESS REDUCTION

Continued rising costs and inadequate cost estimating procedures for the International Space Station Program prompted the Internal Control Council's November 2001 decision to elevate the Station significant area of management concern to the level of material weakness. The Council determined that the longstanding cost growth resulted from underestimating complex program costs and consequent schedule erosion. In addition, in November 2001, the Agency received a major independent evaluation of key reforms needed to correct Station cost and program deficiencies.

Tasked by the NASA Advisory Council, this external advisory subcommittee, the International Space Station Management and Cost Evaluation Task Force, provided recommendations for restoring program management's credibility. This roadmap became the basis of the Agency's corrective action plan that allowed downgrading the Station material weakness to an internally tracked significant area of management concern.

In the year since the task force provided its recommendations, the International Space Station Program Management Team has acted in measured fashion to address the identified weaknesses, choosing the most reasonable strategies and alternative approaches to implementing the recommendations to achieve desired outcomes. While the program management team has not completed all actions to address the task force's recommendations, Station leadership has undertaken strong corrective actions and made significant progress, resulting in the Council's determination that the deficiency level should no longer be classified as material. Significant accomplishments in the Agency's five-point plan to correct Station weaknesses are as follows:

Research Priorities Developed

NASA sponsored an external review and conducted internal reviews to develop research priorities for the Station. The priorities became the foundation for a research plan that defines how best to implement research on the Station that is consistent with the complexities of continued assembly and operations. The NASA Advisory Committee reviewed the plan and found that NASA has made definitive progress in its strategy to conduct scientific research and gain scientific knowledge beyond the engineering feat of Station deployment termed U.S. Core Complete.

Accomplishments in Engineering Development and Deployment

NASA continued to demonstrate technical excellence in the development, deployment, and operation of International Space Station systems. NASA delivered the 43-foot-long, 13.5 ton, S0 truss; installed the Mobile Base System on the Mobile Transporter; replaced the wrist roll joint in the Station's robotic arm; and deployed the S1 truss with radiators and the Crew Equipment Translation Aid. Each of these major accomplishments occurred after the task force had issued its report.

Cost Estimating and Analysis Improvements

The Station is now requirements-driven, based on a solid set of defined needs used to develop our improved program cost estimate. Two external review teams validated the program's internal cost estimate as credible. The program has also developed a work breakdown structure in alignment with its management approach and budget. This structure provides a clear requirements flowdown, including cost, schedule, technical performance requirements, and accountability for risk. The program demonstrated strong FY 2002 cost performance, increasing its programmatic reserve level. The program also developed a method to measure cost and schedule performance while integrating formal earned value reporting requirements into its contracts as part of program-wide reforms in financial management and contract consolidation.

Achievements in Mission and Science Operations

The program management team coalesced in FY 2002, and new leadership implemented definitive cost, schedule, and technical requirements that hold people at all levels accountable. An improved management information system will afford NASA decision makers ready access to accurate and timely information. The consolidation of

26 contracts into fewer than 10 is moving aggressively toward completion, with draft statements of work for industry comment to be released in October 2002.

Improvements in International Partner Coordination

At the Heads of Agency Meeting in June 2002, the International Space Station Partners adopted a new program action plan for enhancing collaborative research use of the Station. In October, the partners endorsed an updated Station assembly sequence that addressed each partner's key concerns and demonstrated their continued strong support for the planned implementation of the program. In the last quarter of FY 2002, NASA continued to make significant progress with the partners through extensive, ongoing coordination and achieved on-schedule each of the critical milestones established in the plan. The partnership is successfully moving toward a December 2002 Heads of Agency meeting, which is expected to endorse a strategy for meeting the Station's utilization and resource requirements and a process for selecting a Station configuration option.

Additional Key Management Information

NASA mentors future scientists and engineers

Alexis Adams, 18, a Huntsville, AL, high school student, works with mentor James Perkins, who leads the Analytical Environmental Chemistry group at NASA's Marshall Space Flight Center. Adams is participating in the Center's SHARP (Summer High School Appren-ticeship Research Program), which helped her discover her love of chemical engineering—and stimulated her decision to pursue it as a career.

PROGRESS IN IMPLEMENTING THE PRESIDENT'S MANAGEMENT AGENDA

NASA is fully committed to implementing the President's Management Agenda. This is a Government-wide effort to improve the way that Government manages in five key areas: Human Capital, Financial Management, e-Government, Competitive Procurement, and Integrated Budget and Performance. The OMB uses a red/yellow/green stoplight rating system to rate agency progress. Green is the best possible rating. The discussion below describes our progress in "getting to green."

The President's Management Agenda provides the central focus for all management reform efforts across the Agency, including our Freedom to Manage initiatives. NASA has established a highly integrated, disciplined process for getting to green with weekly status reports to the Administrator by each of our five President's Management Agenda area champions.

NASA is one of a limited number of agencies to have a written agreement with the OMB on the specific steps required to achieve green; other agencies are seeking to adopt NASA's approach.

Strategic Management of Human Capital

NASA's most valuable asset in accomplishing its mission efficiently, effectively, and safely is the excellence of its workforce. We must ensure that the Agency continues to have the scientific and technical expertise necessary to preserve the Nation's role as a leader in aeronautical and space science and technology, as well as have a cadre of professionals to address NASA's financial, acquisition, and business challenges. Today, however, several converging trends threaten NASA's ability to maintain a workforce with the talent it needs to perform cutting-edge work.

Like other agencies, NASA has an aging workforce with many projected retirements. An additional cause for concern, particularly for a research and development agency like NASA, is that fewer young people are pursuing studies in math, science, and engineering while the demand for such talent is rising in the Government and private sectors. We face skills imbalances, lack of

depth in some critical competencies, and a lack of diversity in the workforce.

NASA already has many programs, activities, and tools to address issues of recruitment, retention, training, and workforce development, and in recent years we have received overall high marks from employees in Government-wide surveys. The current environment, however, makes it imperative that NASA develop—and execute—an integrated, systematic, Agency-wide approach to human capital management that will enable the Agency to work as "One NASA," safely and effectively ensuring that the resources entrusted to us are well managed and wisely used. Critical to this is implementation of the Agency's Strategic Human Capital Plan. Implementing the plan will permit more effective deployment of the workforce across programs and projects, contribute to NASA's ability to attract and maintain a highly skilled, diverse workforce with the competencies NASA needs now and in the future, and enhance mission success.

Key elements of NASA's Strategic Human Capital Plan are reflected in NASA's President's Management Agenda Action plan and summarized in the following text, along with specific actions taken in FY 2002. While the OMB rated NASA red in FY 2002 for strategic management of human capital, the Agency received an assessment of green for substantial progress made in this area during the year.

PMA Step to Green 1. Develop and approve an Agency Strategic Human Capital Plan

A team of NASA senior managers, led by the Assistant Administrator for Human Resources and Education and comprised of several Enterprise Associate Administrators and Center directors or their representatives, assessed Agency management of human capital and identified initiatives to enhance management of this critical resource. Several factors influenced the team's work: internal and external reviews of the Agency's human capital issues; the Administration's emphasis on human capital through the President's Management Agenda; Congressional interest in Government-wide human capital challenges; and nationwide and internal trends that threaten NASA's ability to maintain a highly skilled workforce. Using OMB, Office of Personnel Management (OPM), and GAO standards and tools as guidance, the team established a human capital architecture structured around five pillars: Strategic Alignment, Strategic Competencies, Learning, Performance Culture, and Leadership—the last of which provides the foundation for the others.

While the Agency already has many programs to address recruitment, retention, and workforce training and development, this internal assessment highlighted areas that merit special emphasis. These are establishing an Agency-wide workforce planning and analysis capability; developing a competency management system as part of that capability; increasing use of flexibilities and tools to recruit and retain a highly skilled, diverse workforce; linking students in NASA's education programs with projected workforce needs; ensuring that training and development programs build needed competencies—including leadership competencies—with greater emphasis on knowledge sharing and mentoring; capturing knowledge and lessons learned in a more effective, systematic way; ensuring that Agency performance management focuses on accountability for results; and ensuring that rewards and recognition programs link performance to achievement of Agency goals.

The improvement initiatives were briefed to Agency senior management, and drafts of the Strategic Human Capital Plan and the accompanying implementation plan were vetted with both internal and external customers, stakeholders, and oversight groups—including the OMB, OPM, and the Aerospace Safety Advisory Panel. Successfully implementing the initiatives will greatly enhance NASA's ability to manage its human capital and maintain its preeminence as an excellent organization with a highly motivated, skilled, productive, and innovative workforce—and enhance realization of a "One NASA."

While NASA has addressed human capital in previous strategic and performance plans, our challenge now is to fully integrate the Strategic Human Capital Plan into the Agency's strategic planning, performance, and budgeting processes, including flow-down through Enterprise and Center strategic and implementation planning. The OMB and GAO have underscored the importance of this next step. We have begun this effort. Once in place, the Agency-wide workforce planning and analysis capability and competency management system will enhance our ability to identify and address workforce needs of specific programs. We are also establishing success indicators to help determine whether the initiatives are achieving their objectives.

PMA Step to Green 2. Identify skills gaps in mission-critical areas via an Agency-wide competency management model

NASA's Agency-wide civil service personnel system performs standard personnel administration, payroll processing, and reporting functions. Its capabilities are limited, however, and it lacks the data required for strategic workforce management. Much of NASA's workforce planning and analysis happens at the Center level. This perpetuates ambiguities in roles and responsibilities, contributes to a stovepipe view of the workforce, and inhibits our ability to track and forecast human capital across programs. A more capable Agency-wide system will promote better analysis, planning, management, and alignment of human resources to achieve Agency strategic goals and objectives. An integral element of effective workforce

NASA establishes Educator Mission Specialist position

NASA is looking forward to putting a teacher in space to serve as a mission specialist. Our first Educator Astronaut is Barbara Morgan. To qualify, candidates must have completed the same rigorous training as astronauts with specialties in engineering, physics, or medicine. After graduating with honors from Stanford University, Morgan's career included teaching second grade remedial reading and math at Montana's Flathead Indian Reservation and third grade English and science in Quito, Ecuador.

Morgan is shown here with NASA Administrator Sean O'Keefe in the International Space Station Flight Control Room, Mission Control, during the STS-110/8A mission, April 16, 2002. The photograph was taken four days after O'Keefe announced that Morgan would fly on a Space Shuttle mission scheduled for 2004.

planning—necessary for aligning the workforce with the mission—is the ability to identify existing competencies, those needed, and resulting excesses or gaps. With this capability, we can focus human resource flexibilities—including recruitment tools and employee training and development—on areas of concern to better align the workforce with our mission. We can also better determine which competencies we must retain in-house and which ones we can obtain from industry, academia, and others.

In FY 2002, NASA conducted several demonstrations of our competency management system pilot for representatives from OMB, OPM, GAO, and other Federal agencies. We received high praise for our work. We developed an organizational competency dictionary and are developing a workforce-level competency dictionary. In FY 2003, we will link competencies to NASA class codes and reach agreement on which competencies or occupations the Agency considers mission-critical. We expect to use information derived from this exercise to help shape recruitment of college hires for the summer of 2003. More information on our activities to establish an Agency-wide workforce planning and analysis capability is contained in the Manage Strategically discussion in Part II of this report.

PMA Step to Green 3. Increase the use of human capital flexibilities to recruit, hire, and retain a highly productive workforce

NASA has been aggressive and innovative in using existing authorities and flexibilities. We were one of the first agencies to hire individuals under the Federal Career Intern Program and to use the Student Loan Repayment Program to offer an attractive incentive to prospective new hires. NASA's Centers also use available recruitment, relocation, and retention bonus authority, as well as the superior qualifications appointment authority to attract and retain high-caliber employees.

NASA's FY 2002 Freedom to Manage activities included a review of internal and external barriers to human capital management. It resulted in actions to enhance flexibility and place human capital management accountability where it should be—with Center managers. Specifically, NASA Headquarters delegated numerous authorities to the Centers, including approval of Intergovernmental Personnel Assignments, Senior Executive Service cash awards, and use of NASA Excepted authority. We also provided mechanisms and incentives for hiring nonpermanent employees, reduced the levels of review required for organizational changes, and streamlined the process for Senior Executive Service staffing. These changes enhance the ability of Center senior and line managers to respond quickly to recruitment and retention opportunities.

In FY 2002, NASA also addressed current and future science and engineering recruitment needs by completing a National Recruitment Initiative study. The effort focused on new graduates—often referred to as fresh-outs. The study recommended an agile, flexible hiring model that is candidate-centered, maximizes current networks and forges new relationships to identify highly skilled candidates, and markets NASA as an employer of choice. Several recruitment tools developed from the study appear in the Manage Strategically section in Part II of this report. In addition to these tools, the Headquarters Office of Human Resources and Education collaborated with the Office of Public Affairs on Agency recruitment displays for Centers to use at recruitment conferences, job fairs, and other outreach events. NASA's major program offices cooperated in designing and developing the displays to ensure that they were compelling and illustrated NASA's mission areas and projects.

An issue of considerable concern to NASA is how to maintain a pipeline of diverse new talent from which we can satisfy future competency needs. The Agency

already has several programs from kindergarten through postgraduate to encourage students to pursue science, math, engineering, and technology studies. In FY 2002, NASA began steps to formally make education a core mission area and instituted a more coordinated management approach to enhance our reach and performance in the education arena. The Agency needs, however, a better link between these feeder programs and projected workforce requirements. For this reason, NASA developed a prototype tracking system in FY 2002 to better link students in NASA's education programs to NASA hiring for future workforce needs. In FY 2003, we will analyze data from the pilot and revise the data collection system as needed. More importantly, we will incorporate long-term projections of workforce needs into education program announcements to better leverage our program offerings to meet our need for highly qualified scientists and engineers.

PMA Step to Green 4. Identify new authorities, tools, and strategies that could improve recruitment, retention, competency, and flexibility of the NASA civil service workforce

While NASA makes extensive use of existing personnel authorities, they are not adequate for reshaping and reconfiguring NASA's workforce for the programmatic, technological, financial, acquisition, and business challenges of the future. The authorities' limitations will become more apparent in coming years as NASA's workforce challenges increase because of several broad trends including: fewer science and engineering graduates; greater competition for the shrinking pool of technical talent from both traditional private sector technical employers and newer competitors (for example, the banking and entertainment industries); and the loss of corporate knowledge as key personnel retire.

To address these challenges, in FY 2002 we submitted 11 FY 2003 legislative proposals to Congress through OMB. Many of these enhance authorities that already exist; we proposed the enhancements because we found the authorities insufficiently broad or flexible. The proposals represent an integrated set of human resource flexibilities that will allow NASA to address multiple challenges without jeopardizing important protections or entitlements in areas of merit principles, equal employment opportunity, employee benefits, veterans' preference, and labor relations.

To enable NASA to compete more successfully with the private sector to attract and retain an excellent workforce, the proposals provide for streamlined hiring authorities to allow us to make job offers more quickly, and provisions for more flexible and generous financial incentives, such as recruitment, relocation, and retention bonuses. The proposals to provide more flexibility to the Intergovernmental Personnel Act and create a NASA Industry Exchange Program will enable the Agency to access outside expertise to address skills needs and strengthen NASA's mission capability. To address the long-term need to reverse the shrinking science and engineering pipeline, the Agency proposed a Scholarship for Service Program to offer college scholarships to students pursuing degrees in science, engineering, mathematics, and technology in exchange for a service requirement with NASA after graduation. A provision to permit extension of term appointments up to six years and to allow term employees to be converted to permanent positions will make such appointments more attractive and hence provide the Agency with a more robust labor pool of applicants. Our ability to reshape our workforce to address skills imbalances will also benefit greatly from proposed enhancements to the buyout and early retirement authorities; these authorities will allow us to encourage targeted attrition in areas where the need for skills has diminished and to recruit and reshape a workforce aligned with current and future mission needs. Finally, to respond quickly and effectively to changing employment trends and labor market fluctuations, the streamlined demonstration authority provides a means to test human resources innovations in a manner that other agencies have used successfully for more than 20 years.

We are developing several additional legislative proposals for submission in FY 2004 that will further streamline hiring processes for scientist and engineering positions; provide a more attractive compensation and benefits package to new hires; and improve Senior Executive Service appointment authority to meet short-term staffing needs.

PMA Step to Green 5. Use human capital technologies to maximize productivity of human capital

In FY 2002, NASA completed rollout of an Agency-wide paperless hiring and competitive promotion system—NASA Staffing and Recruitment System (STARS, http://nasastars.nasa.gov/)—to improve the speed of filling vacancies. Statistics available as of September 1, 2002, show that 32,263 resumes were accepted under the new system. Since we enhanced NASA STARS with new applicant services, Web site visitors increased from 30,000 to more than 80,000 per month and a review of the last 3,000 comments on the system's resume builder feature showed that 99 percent were satisfied with the builder and application submission process. The time it takes to acknowledge receipt of a resume or job application dropped from an average of 75 days to less than 1 day because we now send applicants an automatic e-mail response. In addition to internal Agency awards, NASA STARS has received an OMB e-Government award. NASA demonstrated the system to several other Federal agencies.

In FY 2002, NASA also completed final rollout of an Agency-wide automated position description management system. This system permits us to rapidly prepare

and classify position descriptions and automatically generate associated documents. Managers can select position descriptions from an online library or build position descriptions by identifying duties and asking the system to determine the correct series and grade. To date, managers' perceptions have generally been positive; most regard it as a user-friendly program.

In the FY 2001 Performance Report, NASA reported an increased variety of technology-based learning opportunities, as well as increased use of technology-based training. In FY 2002, NASA's Web-based training system Site for On-line Learning and Resources, continued to expand and support Agency-wide training requirements. There are now more than 44,000 user accounts on SOLAR. In FY 2002, about 26,000 tests were taken on SOLAR—most on information technology security.

PMA Step to Green 6. Link employee rewards, recognition, and performance to Agency key goals

Aligning recognition and awards to an organization's goals and expectations is an important strategic tool for managing and aligning employee performance. In the past, NASA established honor award medals to address areas perceived as not receiving adequate acknowledgement, utilized all regulatory flexibilities for cash and nonmonetary awards, and recognized the executive leadership of the Agency with bonuses and Presidential Rank Awards. Each was viewed as a separate and distinct program. Each focused on effort and activities rather than results, without systematically considering their relationship to one another, their alignment with the Agency's goals and expectations, their effect on driving individual performance, and their relevance to mission success.

We established an Agency team in FY 2002 to review how recognitions and awards align with the Agency's performance expectations as they relate to the Agency's mission and goals. After conducting focus groups, benchmarking NASA against 13 private companies, visiting the top five companies, and collecting data to assess the Agency's current state, the team concluded that the alignment is satisfactory. However, the team determined that as a strategic management tool the alignment could be stronger. In October 2002, the team presented its findings and recommendations to the Incentive Awards Board, chaired by the Associate Deputy Administrator and composed of senior management. The board endorsed the team's four proposed management strategies to enhance this alignment: (1) instill more accountability (for example, leadership commitment and clear awards criteria); (2) create additional flexibility for when and how employees are recognized; (3) educate the workforce about the Agency's recognition and awards programs and their relationship to individual employees' performance and contribution to mission success; and (4) manage data for performance results (for example, seek employee feedback and utilize data to analyze the programs' effect on performance).

A final report of the team's findings and recommendations will be published by January 2003. Shortly thereafter, the Office of Human Resources and Education will collaborate with NASA Enterprises and Centers to develop an implementation plan to identify and prioritize improvement actions based on their perceived effect on the workforce. The implementation plan will also call for assessing the improvements and periodically sharing lessons learned.

PMA Step to Green 7. Complete mobility study and pilot/implement actions to expand development activities based on study results

We must optimize our training and development investment consistent with our mission and priorities—as well as maximize the benefits to employees. Sharing program and business best practices across Centers is essential to the development of both our employees and the organization, will foster achievement of "One NASA," and will help us develop the next generation of the Agency's project and business managers and leaders.

In FY 2002, NASA initiated a study to measure the mobility of the workforce; understand the factors that contribute to or impede mobility and rotational assignments; and explore opportunities to increase mobility through developmental activities. We deployed a Web-based survey in mid-July to about 9,000 NASA employees, received more than 4,000 responses, conducted focus groups at five Centers, and are now analyzing the data. After the study's completion in December 2002, we expect to develop and pilot recommended actions by October 2003.

PMA Step to Green 8. Establish strategies for leadership/knowledge management continuity

NASA's leadership training and development programs are comprehensive. Beginning with the NASA Leadership Model, the Agency has placed emphasis on evaluating and developing leaders through evaluation instruments, local and distributed learning opportunities, workshops, seminars, conferences, and resident classes. However, we can do more. Given current workforce demographics, it is paramount that we focus on capturing and making available the wealth of expertise and experience that exists across the Agency. Employees in leadership positions should not only pursue their own professional growth but also share their practical experience with those who will follow them. We must select participants in leadership development programs by thoughtfully considering both their leadership potential and the Agency's future needs.

In FY 2002, we established a team to create an Agency-wide strategy to help Centers use coaching more

effectively to improve performance and enhance mission results. The team conducted an Agency-wide session to examine coaching approaches and followed up by developing draft guidelines for Agency-wide use. We will provide these guidelines shortly to the Centers.

NASA began an effort to foster NASA communities of practice expressly to capture and communicate project knowledge and wisdom resident in NASA. As part of this effort, project management experts gather periodically to share their stories, promoting learning, mentoring, and leadership development. In the past year, NASA conducted a Project Management Shared Experience session and two Masters Forums. Participants from NASA aerospace and non-aerospace projects shared their project management experiences. Many stories are captured in the ASK (Academy Sharing Knowledge) magazine, available in print and online at http://appl.nasa.gov/knowledge/ask_home.htm. The publication provides a further mechanism for communicating these lessons. Practitioners have adopted new management approaches based on their colleagues' stories and lessons because of this 18-month effort. In addition, NASA developed a preliminary knowledge-sharing and mentoring plan. After stakeholder review, this plan will become final in late October 2002.

Plans include renewed emphasis on effective management of the Agency's Senior Executive Service. The Senior Executive Service was a keystone of the 1978 Civil Service Reform Act and was designed to be a corps of executives selected for their leadership qualifications—not their technical expertise. It is a group charged with leading the continuing transformation of Government, which is essential as we implement the President's Management Agenda at NASA. It is critical that we appoint, promote, reward, develop, and recognize the right executives, for the right reasons, at the right time. In the coming year, NASA will study criteria used to make Senior Executive Service appointment decisions; criteria for making the service's promotion and bonus decisions; ways to create communication, collaboration, and camaraderie among the Agency's executive leadership; whether the service's cadre needs additional development; and whether we need additional development and succession planning for future leaders at the higher grades of the General Schedule but below the Senior Executive Service level.

Competitive Sourcing

NASA sees competition as the tool of choice to ensure that we are getting the best value for the taxpayer. NASA is aggressively applying the pressure of competition to both the 87 percent of our budget that we contract out and the 13 percent that remains in-house. We are proud to report that we awarded 78 percent of our contracts competitively in FY 2002 and we are taking steps to increase that percentage.

The Competitive Sourcing Plan submitted to OMB in June 2002 necessarily addressed only the in-house 13 percent of the budget; the other 87 percent is already performed under contract. The goal of competitive sourcing as it applies to NASA is to expose certain in-house activities that are not inherently governmental, referred to as commercial activities, to competition. We examined our inventory of activities available for competition and developed a plan to directly convert them to contractor performance, capitalize on ongoing contract conversions, or compare in-house activities with contractor performance. Our plan achieved the President's Management Agenda's goals for FY 2002 and FY 2003 by the end of FY 2002.

NASA's greatest strength in implementing competitive sourcing is that, from early in its existence, NASA has contracted with the private sector for most of the products and services it uses and hence has a strong tradition of being a wise shopper. NASA's greatest challenge in implementing competitive sourcing is that we have already contracted out most of the support service activities that we saw as available for outsourcing. We are now considering contracting out even more of the efforts associated with operating the Shuttle and the Station.

PMA Step to Green 1. Submit Federal Activities Inventory Reform (FAIR) Act Inventory to Office of Management and Budget

NASA prepared a high-quality inventory of its commercial and inherently governmental activities. Instead of building on the inventories of prior years, NASA initiated a bottom-up approach to developing the 2002 FAIR Act inventory. This process included establishing a dedicated Agency Competitive Sourcing team and a Competitive Sourcing Review Board composed of senior managers at NASA Headquarters. These units provided consistent, detailed instructions to NASA Centers on how to classify activities as either commercial or inherently governmental. This effort resulted in a 70-percent increase in the number of full-time employees in positions identified as commercial compared with the 2001 inventory: NASA's 2001 inventory identified 4,333 full-time employees as commercial; in 2002 we increased that number to 7,405. That increase means that potentially more NASA activities will be available for competition. The OMB included NASA's inventory in the first notice-of-availability published in the Federal Register in October 2002.

The greatest challenge we faced in this activity was overcoming the mindset that every activity that has been performed by a Government employee is permanently inherently governmental. The FAIR Act inventory is an annual event. Now that we have developed a proven process that yields a high-quality product, NASA anticipates that developing other inventories would be less labor-intensive. However, OMB recently proposed reissuing Circular A-76, which would have a profound

effect on the inventory process. In any event, NASA will continue to refine the inventory process to ensure consistent classification of activities as commercial or inherently governmental.

PMA Step to Green 2. Submit Competitive Sourcing Plan to Office of Management and Budget

On June 26, 2002, NASA submitted its first-ever Competitive Sourcing Plan to OMB. To develop the plan, NASA Headquarters provided uniform guidance to all NASA Centers, each of which then developed its own plan. Headquarters synthesized these. The resulting Agency-level plan exceeded OMB's FY 2003 goal of exposing 15 percent of commercial activities to competition by the end of FY 2002. Rather, it provides for a 19-percent exposure to competition by the end of FY 2003 and a 40 percent exposure by the end of FY 2007.

With regard to challenges, the plan is an interim one because it does not yet include the Station and the Shuttle. NASA is carefully studying both programs for potential competitive opportunities. Further, the President's Management Agenda asked for all agencies to strive toward a 50 percent goal. That may not be attainable for NASA, given the great extent of outsourcing that NASA already performs. In any case, we will continue to monitor progress against the plan and include the Shuttle and the Station in it as soon as key decisions are made on those programs.

PMA Step to Green 3. Office of Management and Budget approval of Fair Act Inventory

The OMB accepted the inventory that NASA submitted and included it in the first round of notices of availability they published in the Federal Register. It took concerted effort to obtain OMB approval; when OMB suggested increasing the number of commercial activities in the inventory, we improved the quality of the inventory process. The proportion of commercial activities in the resulting inventory exceeded OMB's expectation. NASA will use the same inventory process next year, applying refinements from lessons learned.

PMA Step to Green 4. Office of Management and Budget approval of Competitive Sourcing Plan Phase I (15 percent)

Our Phase I Competitive Sourcing Plan achieved the President's Management Agenda goal for FY 2003 in FY 2002. The OMB had asked for one, all-encompassing plan. Our challenge here was that we knew that key decisions on the Station and the Shuttle would not be made in time to support the timely submission of the plan. Therefore, we developed a plan divided into Phase I (through FY 2003) and Phase II (through FY 2007) to accommodate the ongoing decision process and still substantially achieve the goals set forth in the President's Management Agenda. The OMB approved the Phase I Plan but recognized it as interim until the Station and the Shuttle are addressed and included. We expect to submit our final Competitive Sourcing Plan, including Station and Shuttle considerations, in June 2003.

PMA Step to Green 5. Office of Management and Budget approval of Competitive Sourcing Plan Phase II (50 percent)

Our Phase II Plan achieves a 40-percent goal in FY 2007. There are two challenges here. The Phase II Plan will address competitive sourcing of the Shuttle and the Station. NASA is deliberating those considerations now before we present recommendations to the Administration. The political and economic consequences of those recommendations will certainly require careful review, which makes it difficult to predict a final decision date. In addition, the President's Management Agenda calls for all agencies to aim for goals of 50 percent. Depending on the outcome of the Shuttle and Station competitive sourcing considerations, that goal may not be achievable for NASA because so many of our activities are already done under contract.

PMA Step to Green 6. Begin implementation of Office of Management and Budget-approved Competitive Sourcing Plan (Phase I)

By the end of FY 2002, we had successfully converted 749 of the 874 full-time employees (86 percent) in Phase I from the public to private sector. During the nonselective downsizing of the Federal workforce in the 1990s, NASA developed a skills imbalance that weakened our core competencies—our ability to fulfill our basic mission. We were unable to correct this problem because of personnel ceilings. Our solution was to rebalance the workforce by reducing personnel strength in noncore activities and substituting core activities. Therefore, our Competitive Sourcing Plan weighs more toward outsourcing noncore activities. The Centers are on schedule to complete Phase I as planned. NASA Headquarters will monitor their progress.

PMA Step to Green 7. Begin implementation of Office of Management and Budget-approved Competitive Sourcing Plan (Phase II)

NASA submitted a Phase II Plan that exposes 40 percent (cumulatively with Phase I) of activities identified as potentially commercial to competition in FY 2007. Achieving that goal is a major accomplishment given that NASA from its earliest years has contracted with the private sector for most of the products and services it uses. We have begun implementing the plan.

PMA Step to Green 8. Complete inventory of interservice support agreements

To identify potential opportunities for competition, OMB requested that NASA inventory its interservice support agreements, federally funded research and development centers, university-affiliated research centers, university research engineering and technology institutes, commercial space centers, and similar partnerships. We did so and provided the inventories to OMB. NASA conducted the inventories based on internally developed ground rules; for example, only agreements with a value greater than $1 million were included. Any further plans are contingent on OMB approval or discussion of the inventories.

PMA Step to Green 9. Develop Office of Management and Budget plan for competing interservice support agreements

The OMB has approved the inventories; we are now developing the competition plans.

NASA's final Competitive Sourcing plan must include plans for competing interservice support agreements, Federally funded research and development centers, university-affiliated research centers, university research engineering and technology institutes, commercial space centers, and similar partnerships. A significant amount of NASA work is being accomplished under these partnership arrangements. A significant amount of NASA work is accomplished under these partnership agreements. In addition, we plan to inject greater competition wherever sizable contract actions are involved (for example, previous sole source awards, exercise of options, and contract extensions). While most of the processes for awarding partnerships and contracts already entail competitive practices, only a careful review of all processes will ensure a truly competitive environment.

Expanded Electronic Government

NASA is a Federal Government leader in providing electronic services to our citizens, business partners, employees, and stakeholders. We were one of the first Federal agencies to realize the potential of the Internet in delivering information and services to the public and have consistently received recognition for the number and variety of Web sites and electronic resources that we provide. NASA has been of particular help to the educational community by providing first-rate electronic services and online information to U.S. teachers and students.

To maintain this position of excellence, we must continue to provide superior products and services to our customers. We must use e-Government to unify and simplify access to NASA's information, helping our customers locate and use information quickly and efficiently. We must expand our e-Government products and services to provide information in all practical formats, at all times, to all audiences. We must strengthen our information technology infrastructure so that we can provide cutting-edge services and technologies reliably and securely. We must provide online, collaborative environments that support interactions within NASA and between NASA and our industry, academic, and international partners. With these challenges in mind, NASA has undertaken an ambitious set of activities to expand e-Government and achieve green status on the President's Management Agenda scorecard. We participate in e-Government activities that span Agency boundaries, including several Federal e-Government projects coordinated by the President's Management Council. We are revamping the Agency's information technology infrastructure to ensure that we can provide secure, highly reliable, and cost-effective systems and services to support NASA and our customers. We are redesigning the Agency's Web presence to make it easier for users to locate what they need quickly. We are analyzing NASA information technology initiatives to identify potential opportunities for streamlining and process improvement, and are investigating other e-Government products and services that could benefit the Agency. Finally, we are improving our electronic systems' security to ensure that NASA's critical information assets are protected and that electronic transactions within NASA and with our customers are private and secure.

NASA is implementing new features in our President's Management Agenda e-Government plan beginning in FY 2003. While the new plan will focus on many of the same key activities as the previous plan, the new plan aligns more closely with the "One NASA" vision and goals. This report primarily reflects NASA's accomplishments in FY 2002 under the previous plan, although in places it also references the new plan.

PMA Step to Green 1. Achieve internal efficiencies by leveraging technology

In FY 2002, NASA outlined plans to improve its common information technology infrastructure and services. We made a significant effort to assess our network infrastructure, identify needed improvements, and implement appropriate technical solutions. Our first step was to create the NASA Information Systems Services Utility in May 2002, to provide a reliable, secure, and low-cost information infrastructure for all Agency systems and services. In a related effort, we analyzed our wide area and local area networks, electronic messaging systems, and desktop computer configurations to identify opportunities to improve services. These analyses will lead to detailed action plans that we will implement in FY 2003 and beyond.

Strengthening NASA's infrastructure will give NASA's researchers, scientists, project managers, and administrative employees the access to technologies needed for everyday work. Most significantly, it will provide a reliable backbone for the new Integrated Financial Management (IFM) system's core modules. All of these improvements will allow our researchers and project leaders to focus on program efforts to benefit the Nation and humankind.

NASA must consider several challenges in pursuing these activities. We are a distributed Agency and conduct our missions from diverse geographic locations. This makes it both essential and difficult to have a well-functioning network. The primary goal of this activity is smoothly and seamlessly transitioning the Agency to better information products and services without adversely affecting mission operations.

We will continue improving the Agency's infrastructure and services in FY 2003. This includes establishing the Information Mission Control Center. This facility, based on concepts that NASA developed for space travel mission control, will provide a central interface for NASA's networks and related services. Also planned for FY 2003 is an Agency-wide messaging system to improve e-mail services by using a standard approach across NASA.

PMA Step to Green 2. Deliver superior information services to the American citizen

NASA continued to provide superior information products and services to the American citizen in FY 2002. In addition to maintaining and improving our many public Web sites, we initiated a complete redesign of our main Web site, the NASA homepage. In late FY 2002, we issued a request for proposals to obtain input on a potential redesign. Many of America's best and brightest Web design and marketing experts submitted ideas. We conducted an initial review of the submissions in FY 2002. When completed, the redesign promises to be an inspiring reflection of NASA's exciting mission and vision.

Our redesign will include a new look and feel, a better search engine, and links to our most useful information. We will integrate the Agency's top Web sites to allow users to readily locate them through search and browse functions on our main page. Because NASA has been recognized for our contributions to the educational community, we will focus on providing information to educators and students through Web resources targeted to them.

One of the challenges of e-Government is ensuring that NASA can conduct transactions with American citizens in a secure environment. The OIG identified the implementation of NASA's e-Government initiatives as a top management challenge in its February 2, 2002, memorandum to the NASA Administrator. Of particular concern to the OIG was NASA's ability to maintain the security of our electronic systems and the privacy of the individuals who use them. NASA takes information security very seriously, and we continue to emphasize the need to rapidly identify, track, and resolve all information technology security issues. We are committed to protecting our relationships with customers, stakeholders, and business partners.

PMA Step to Green 3. Improve intergovernmental efficiency through collaboration

In FY 2002, NASA participated in a number of the Federal e-Government initiatives coordinated by the President's Management Council. This included serving as a managing partner in the e-Authentication, Recruitment One Stop, Enterprise Human Resources Management, and Geospatial One Stop initiatives, providing significant staff and resources to each activity. The Federal e-Government community has recognized NASA in these four areas for our leadership and expertise. We also participated in the e-Training initiative, sharing lessons learned from our experience and benefiting from the expertise of other agencies in this area. We continue to identify opportunities to participate in the Federal e-Government arena.

Implementing these initiatives may cause great changes in NASA's business practices. Although the result of these changes is almost certain to be positive, we will have to make sure to manage change carefully as we introduce new technologies across the Agency. NASA recognizes that simply automating an existing process is not sufficient: we must improve operations through constructive organizational change. Many of the Federal e-Government initiatives will provide us with an appropriate impetus for such change.

NASA will continue participating in the Federal e-Government initiatives that are most relevant to our mission and vision. In addition to the initiatives previously identified, we will provide technical leadership in the rollout of an initiative to provide standardized smart identity cards for Government employees. This promises to be an exciting focus area for NASA and the rest of the Federal community.

PMA Step to Green 4. Reduce the burden on business through e-Government

In FY 2002, NASA continued to provide strong support for the Integrated Acquisition Environment and e-Grants activities. We undertook many efforts related to the former. These included a project to centrally register our contractors to help build a searchable catalog of Federal contractors, a Web-based system allowing agencies to collect and report procurement data electronically, and identification of opportunities to standardize Federal procurement processes and tools. With respect to e-Grants, we have worked closely with other agencies to identify potential ways to standardize the grants application

process. All of these initiatives would benefit our business partners by simplifying the processes and forms required to do business with the Federal Government.

A critical challenge that NASA faces in this area is ensuring the ability of the Agency to interact smoothly with our business partners. We need to be certain that the decisions we make in adopting new processes and technologies are compatible with the processes and technologies our industry partners use. NASA plans to utilize industry standards such as the use of Extensible Markup Language (XML) to facilitate interactions between diverse information systems and services.

We plan to continue participating in Federal e-Government initiatives to support Government-to-business transactions. NASA is also investigating the possibility of joining a major aerospace industry e-commerce exchange. In early FY 2003, NASA will study the feasibility of using an online exchange to foster relationships and facilitate transactions with the Nation's leading aerospace and defense companies. This could help streamline interactions with our major business partners.

Financial Management

Our goal in implementing the financial management initiative in the President's Management Agenda is to establish and maintain a single, integrated financial management system and provide timely, accurate financial data and reports. NASA is challenged with reengineering our business infrastructure to align with industry best practices and implementing enabling technology to provide management information to help us implement our Strategic Plan, provide better decision data and more consistent information across Centers, and improve efficiency and effectiveness. NASA's strategy to accomplish these aims is to (1) successfully implement our new IFM system and (2) resolve our material weakness and regain a clean audit opinion on our financial statements.

PMA Step to Green 1a. Integrated Financial Management Program (IFMP) core finance at pilot center

We completed developing and testing the core financial module of the IFM system in preparation for implementing the module at the pilot center in October 2002. The core financial module will give NASA an incredibly powerful financial management capability. NASA will be the first Federal agency to utilize the full capability of SAP AG's financial management system. We anticipate that it will uncover several issues in the areas of full appropriated funding, complex contracting, Federal standard General Ledger, and full-cost management. In addition to technical issues, there is a significant change-management challenge as standard Agency processes will replace the individual processes now employed across our 10 Centers. The pilot center faces the complication of completing an Agency design that applies to all 10 Centers while concurrently trying to implement the pilot locally. Because the pilot will be going live at the start of a new year, there is a time constraint and dependency on closing out the legacy financial systems that adds schedule risk.

The core financial module will provide NASA managers with tools to enable them to implement full-cost management and tie programmatic decisions, financial effects, and Center infrastructure together to support their decision process. When the system is complete, NASA decision makers will have access to integrated financial and business systems, automated processes, and consistent data in real-time. This should improve our ability to receive an unqualified opinion on financial statements.

PMA Step to Green 1b. IFM System implementation: wave 1 centers

We completed developing and testing the core financial module of the IFM system in preparation for implementing the module at the wave 1 center (Glenn Research Center) in October 2002. Because the two Centers are going online at the same time, the challenges at the Glenn Research Center mirror those at the pilot center. Initially the Glenn deployment was planned to follow the pilot center by 4 months. Software problems delayed the pilot and now the two Centers are deploying together. Glenn has a shorter overall implementation timeline and lacks the advantage of proven procedures. Glenn has the additional challenges associated with physical separation from the project team that resides at the pilot center. The benefits are the same as those described in step 1a above.

PMA Step to Green 1c. IFMP implementation: wave 2 centers

Development and testing of the core financial module of the IFM system was conducted in preparation for implementation of the module at the wave 2 centers (NASA Headquarters, Johnson Space Center, Kennedy Space Center, Ames Research Center), scheduled to roll out in February 2003. The wave 2 centers have the benefit of learning from the rollout at Marshall and Glenn. The software and procedures for rollout have been demonstrated and there should be fewer implementation issues to resolve. They have the added complication of having to go live at four Centers concurrently. Their delivery schedules, data conversion activities and system testing are integrated, which means there is a significant codependency. They also have to integrate with an existing production system at the first two Centers that adds complexity. Lessons learned during the implementation of the module at the pilot center and wave 1 center will assist in the implementation at wave 2 centers.

PMA Step to Green 1d. IFMP implementation: wave 3 centers

We developed and tested the core financial module of the IFM system in preparation for implementing it at the wave 3 centers (Dryden Flight Research Center, Goddard Space Flight Center, Langley Research Center, Stennis Space Center), scheduled to roll out in June 2003. The challenges at the wave 3 centers are similar to those in wave 2 except that wave 3 has the advantage of learning from six previous Center experiences. There is additional scope in this final wave to integrate the individual centers into a single Agency system. With wave 3, the existing Agency-level financial and contractual status (FACS) system will be replaced. The lessons learned during the implementation of the module at the pilot center and the wave 1 and 2 centers will assist in the implementation at wave 3 centers.

PMA Step to Green 1e. IFMP implementation: Interim MIS

Erasmus, NASA's financial dashboard, is a Web-based system that provides all levels of NASA's leadership with accurate, timely, comparative performance reports on all major programs and projects using a standard, integrated set of data. In the Erasmus prototype, 16 programs provided data for the initial trial. All remaining NASA programs and their projects are scheduled to begin entering data into the system by the end of October 2002.

Although programs and projects have reported performance data in the past, different and inconsistent reporting techniques made evaluating and comparing programs and projects across NASA difficult. This weakness was highlighted by the Young Commission in 2001. Erasmus is the initial step toward meeting significant challenges in program and project performance reporting. The Erasmus system and business principles provide a single, visible repository to report cost, technical, and schedule performance across NASA. A consistent taxonomy enables executives and managers to compare key indicators of the health of programs and projects.

Erasmus will serve as a pathfinder for a more comprehensive reporting and information delivery system to be implemented as part of the IFMP. It will enhance program and project manager's accountability, allowing them to explore the financial reporting information provided by other managers to discover best practice, cost-saving, and improved resource management opportunities.

PMA Step to Green 2a. Audited financial statements: resolution of all outstanding FY 2001 issues

A team drawn from the Office of the Chief Financial Officer, Center finance staff, and technical staff have worked with NASA's auditor, PricewaterhouseCoopers, to address the problems PricewaterhouseCoopers reported in its FY 2001 financial statement audit. The problems regarding sampling of accounting data have been resolved and an alternative approach was utilized in FY 2002. NASA management resolved prior year asset classification issues and finalized the opening balance sheet for the FY 2002 audit. NASA also worked with its auditor to better understand documentation and sampling shortfalls experienced during the FY 2001 audit.

The above activities addressed and resolved the FY 2001 audit issues. Due to the fact that property, plant and equipment and materials is still being reported as a material weakness, NASA must continue to improve overall internal controls surrounding these two areas including providing property, plant, and equipment and materials training and guidance for NASA and contractor property administrators, improve reporting procedures for contractor-held property, and emphasize monitoring and enforcement activities.

NASA will make effective use of software solutions provided by SAP AG to improve financial statements. In addition, we will use lessons learned from the FY 2001 audit to improve the asset valuation methodology and supporting documentation to provide greater assurance regarding the capitalized value of property, plant, and equipment reported on the financial statements.

PMA Step to Green 2b. Audited financial statements: Closing of FY 2002 General Ledger

NASA management resolved prior year asset classification issues and finalized the opening balance sheet for the 2002 audit. The FY 2002 General Ledger and subsidiary data in the Financial and Contract Status system have been closed and reconciled. NASA provided PricewaterhouseCoopers with the detailed transactions for FY 2002 to support the auditor's selection of a sample from which to request documentary evidence.

The transition from individual legacy systems at each NASA Center to one integrated solution will present challenges until the new business process becomes familiar. NASA must maintain the integrity of the financial and contractual status database through monthly reconciliations and validation of data inputs. Data sampling will be simpler in the new SAP AG accounting system, which provides an integrated database that has drill-down capability. Increased quality-assurance review capabilities will be available with the new software solution.

PMA Step to Green 2c. Audited financial statements: "clean" audit opinion

Actions taken in FY 2002 to obtain NASA's clean audit opinion include forming an informal audit committee (NASA and the OIG) that we plan to formalize at higher level in the future. We held biweekly and weekly audit status meetings to stay aware of any issues that might arise during the audit. The audit process began earlier in the FY 2002 audit cycle. NASA personnel visited centers to

review data and meet with contractors and program office personnel. The Defense Contract Audit Agency portion of the audit plan was revised for FY 2002. NASA personnel accompanied PricewaterhouseCoopers to Center audit visits. NASA has worked with its auditors to better understand documentation and sampling shortfalls reported in FY 2001. Completion of the audited financial statements is in progress and on schedule.

Integrated Budget and Performance

NASA has pursued an ambitious plan to integrate its budget with its performance plan and its budget formulation process with its performance measurement system. NASA brought to this task a key strength: we had already begun reorganizing the strategic plan, performance plan, and budget around 18 budget and program theme areas. The themes lay the groundwork for integrating budget and performance by aligning both with the Agency's management framework: an activity's budget is now directly traceable to the results we expect to achieve from it. The benefits of this approach are twofold. First, it helps NASA's stakeholders—the American public—understand the value of an investment in a given program. Second, it clarifies to our workforce the specific ways in which their work supports the Nation's priorities.

NASA defined its full cost budgeting, management, and accounting approaches in an implementation guide that we have used for planning for the past 2 years. During this same period, we used a new Agency-wide budget formulation process drawing on a single database to collect and review budget recommendations from the project level through the Center, Enterprise, and Agency decision levels. We also used this system to produce all budget submission information. Despite these efforts, OMB's initial President's Management Agenda scorecard rated NASA's status for budget/performance integration as red, or unacceptable: while our efforts were significant, they still fell short of full cost budgeting and management. Since then, however, we have made rapid progress, preparing a representative recast of our FY 2003 budget submission in full cost and submitting our FY 2004 budget request in full cost.

PMA Step to Green 1. Recast FY 2003 budget in full cost

While the Enterprises contributed to the Full Cost Implementation Plan developed in 1999 and worked with the Centers to design processes for developing cost pools, they had not prepared actively to review their budgets in full cost terms. The Office of the Chief Financial Officer provided a full cost recast of the FY 2003 budget, tracking sheets, and briefings to help the Enterprises transition their budgets to full cost.

PMA Step to Green 2. Develop FY 2004 full cost budget

NASA submitted its FY 2004 budget to OMB in full cost on September 9, 2002, and briefed them on the full cost background material several days later. We provided the budget and supporting documents through an electronic clearinghouse, e-Budget. We prepared the full cost budget using the existing NASA Budget System database with procedural modifications pending availability of a new database. These accomplishments fulfill the negotiated steps for achieving a yellow rating on this criterion.

PMA Step to Green 1. Demonstrate Agency-wide use of full cost budgeting and management

Achieving a green rating for this criterion depends on the Agency demonstrating by December 2003 that is routinely using full cost budgeting, management, and accounting procedures. NASA will provide further training to increase the Agency's ability to make budget decisions and to manage using full cost considerations. We are also defining a new automated budget formulation module to enhance the full cost budgeting process; this will be fully available in 2004.

PMA Step to Green 4. Performance Assessment Rating Tool (PART) provided for 20 percent of programs/theme areas per Office of Management and Budget spring review

The PART is an evaluation tool that OMB is phasing in across the Federal Government. After extensively testing the tool, OMB asked the agencies to apply it to selected programs to ensure that it properly assesses performance. At the spring review, NASA presented its results from a first application of the tool. NASA subsequently worked with OMB again on rating the programs with an updated version of the tool. The results will be disseminated to Congress and the public.

The spring review was a challenge because PART is very new. NASA had to identify the process and the officials responsible for generating the data to be used for the assessment. The detailed nature of the tool meant that it was necessary to disseminate OMB's success criteria and program management best practices throughout the Agency. NASA's scores improved considerably between the spring review and the September review, demonstrating that NASA is meeting this challenge.

The tool will be applied to an additional 20 percent of Federal programs each year until it becomes a standard assessment tool for all programs. As OMB refines the tool based on this year's feedback, NASA will be able to identify program management changes needed to continue to improve our scores. As we apply the tool to other NASA programs for the first time, maintaining a green status will require us to demonstrate the same high standards of performance we showed in the first 20 percent.

Challenge and Risk Identification

Management Challenge / Risk Area / Initiative	General Accounting Office Report 02-182	Office of Inspector General Letter 12-01-2000	Office of Inspector General Letter 02-04-2000	President's Management Agenda
Strategic Human Capital Management	O			O
Information Technology/ Information Technology Security	O	O	O	
E-Government Initiatives			O	O
International Space Station Program Management and Development and Support Costs	O	O	O	
Integrated Financial Management System			O	
Safety and Mission Assurance		O	O	
Launch Vehicles		O	O	
Security of NASA Facilities and Technology			O	
Procurement/Contract Management Weaknesses/ Competitive Sourcing	O	O	O	O
Cost Estimating			O	
Environmental Management/ National Environmental Policy Act Implementation		O	O	
Plum Brook Reactor Decommissioning			O	
Effectiveness of Faster-Better-Cheaper for Space Exploration	O			
Fiscal/Financial Management		O		O
Program and Project Management		O		
Technology Development		O		
International Agreements		O		
Integrated Budget and Performance				O

PMA Step to Green 5. Develop performance budget document concept with Office of Management and Budget

NASA's Integrated Budget and Performance Document meets the combined requirements of several separate documents, including the OMB budget submission, the President's Budget of the United States submitted to Congress, and the annual performance plan. The OMB has reviewed and approved the Integrated Budget and Performance Document concept and the templates for the required information. The document goes beyond simply putting the budget and the performance plan in the same cover and imposing a similar structure on both documents. Because of the theme approach noted above, a program's budget and the expected performance are on the same page along with a clear argument as to why an investment in this theme is important and relevant. Presenting information in this way makes it easier for the public, Congress, and OMB to see clearly what to expect from NASA in the next year.

We faced many challenges in pursuing a green rating in this area. However, once we meet all of these challenges, we do not expect any of them to jeopardize our ability to maintain that green rating. The greatest challenge was to replace the documents that had been meeting the separate requirements of budgeting and performance measurement with a single document in a timely manner. To do this, we conducted an extensive design, comment, and refinement process, working to ensure that the Integrated Budget and Performance Document was as finely tuned to the requirements as its predecessor documents had been.

This resulting document benefits from lessons learned from many disciplines at NASA, including budget formulation, performance measurement, program management, risk management, procurement, and strategic planning. Continuous improvement will fold in the feedback and emerging best practices of these disciplines and the NASA stakeholder community. For instance, NASA expects performance measurement to continue to improve every year through feedback from independent reviewers and new initiatives like the President's Research and Development Investment Criteria.

PMA Step to Green 6. Submit budget through electronic clearinghouse

After extensive testing through the summer of 2002, the NASA e-Budget electronic clearinghouse was deployed for the September 9, 2002, budget submission to OMB. This clearinghouse provides NASA and OMB a quick, secure, and interactive channel to manage the various documents passed back and forth. The system allows both organizations to post official materials, check their status, and approve them.

The benefits of this new approach derive from better communication. The data sharing that must occur is significant. To provide budget guidance and oversight, OMB must be able to receive, review, and approve this data in a timely manner. Because of its sensitive nature, in the past, the data were often hand-carried between the organizations. The secure e-Budget clearinghouse offers a solution to this inefficient process.

The most significant obstacle to achieving a green status was security. So long as the budget data are embargoed, data may be shared only among the NASA budget community and with OMB. While the clearinghouse is convenient, the challenge of safeguarding the information using a secure Internet site remains. The e-Budget system complies with all NASA security policies and guidelines, as well as industry standards for handling Business and Restricted Technology.

No remaining challenges to maintaining a green status exist. NASA expects that extending the clearinghouse concept to the IFM Program and the e-Government Program will result in yet more efficiency and efficacy in our dealings with OMB.

PMA Step to Green 7. Submit performance budget document to the Office of Management and Budget

Because it was a new process and a new product, we received permission to provide the Integrated Budget and Performance Document to OMB in a phased delivery. We provided the first pieces on September 9, 2002, as part of the budget submission process. This first deliverable demonstrated that the newly designed and agreed-upon templates could be filled out and produced. This pilot effort included the data for three complete theme areas and all the data for all development programs Agency-wide. The theme areas were the same three that we had filled out for PART, making it possible to test and evaluate both documents together. Providing Integrated Budget and Performance Document materials on development programs did double duty for another development-program evaluation form that NASA normally provides to OMB every September, the 300B form.

The phased approach mitigated many potential challenges. In meeting the diverse requirements of both the budget formulation and the performance measurement processes, we were faced with conflicting deadlines in producing the new Integrated Budget and Performance Document. The OMB required some of the data in the September timeframe, while some of the data—such as program narratives—are traditionally submitted in the December timeframe. The phased schedule agreed to with OMB ensured that OMB would have the data when needed.

NASA expects to finalize the submission of the performance budget without major difficulties. Two phases remain. NASA expects the second phase of the submission to contain all of the pieces of the document for initial OMB review. In the third and final phase of the submission, NASA expects to submit the final performance budget incorporating all OMB guidance to prepare for the submission of the President's FY 2004 Budget of the United States to Congress.

PMA Step to Green 8. Submit NASA budget using performance budget document concept

NASA and OMB expect to use the Integrated Budget and Performance Document as the President's FY 2004 Budget submission to Congress in February 2003. We foresee no impediments to achieving a green rating. NASA and OMB have reviewed and approved the performance budgeting approach. The phased delivery of the actual document to OMB occurred in a timely manner. We anticipate extensive feedback from Congress on our performance budgeting approach.

MAJOR MANAGEMENT CHALLENGES AND HIGH-RISK AREAS

In FY 2002, a major focus at NASA was improving management. This included many common-sense-based changes, the Freedom to Manage effort that implemented employee suggestions on how to accomplish work more efficiently and effectively, and a concerted effort to address specific issues raised by GAO and OIG.

The GAO's November 2001 report GAO-02-184 "NASA: Status of Plans for Achieving Key Outcomes and Addressing Major Management Challenges" and the two most recent OIG letters about NASA's most serious management challenges (dated December 1, 2000, and February 2, 2002) call attention to some 17 major management challenges and high-risk areas. In many cases, the reports cite the same or similar issues; the following discussion will not double count these. Some of the issues are the same as or closely related to four of the five Government-wide President's Management Agenda issues discussed above, confirming that while some of NASA's challenges are unique, we share many of the same challenges facing other agencies. The table above shows the distribution of these issues among the previously mentioned reports and the President's Management Agenda initiatives.

The previous section describes in detail NASA's efforts in FY 2002 to implement the President's Management Agenda initiatives. This discussion will focus on our response to GAO's and OIG's findings. Where the response is identical to our President's Management Agenda activities, we will refer the reader to that section of the report rather than duplicating its discussion. While GAO and OIG sometimes make recommendations with which we disagree, the audit process overall is healthy, engendering debate and new thinking about how to accomplish our mission and leading ultimately to an Agency that is better able to fulfill its mission.

Strategic Human Capital Management

With regard to Strategic Human Capital Management, GAO cited key elements including strategic planning and organizational alignment, leadership continuity and succession planning, and acquiring and developing staffs whose size, skills, and deployment meet Agency needs. Foremost, we addressed these concerns by developing a Strategic Human Capital Plan and an accompanying Strategic Human Capital Implementation Plan. The preceding section of this report discussing the President's Management Agenda fully describes this effort. NASA is working to integrate its Strategic Human Capital Plan into the Agency's strategic planning, performance, and budgeting processes to meet Enterprise, Center, and program objectives. Once in place, the Agency-wide workforce planning and analysis capability and competency management system will enhance the ability to identify and address workforce needs of specific programs. We hope and expect that these steps will go a long way toward addressing this key GAO issue.

Procurement/Contract Management Weaknesses/Competitive Sourcing

Procurement-related issues arose in both of the OIG's reports, the GAO report, and the President's Management Agenda. The GAO identified NASA contract management as high-risk for two reasons: past delays in implementing the IFM system and its use in full cost accounting, and the continued reliance on undefinitized change orders. (Undefinitized change orders are contract modifications that are likely to increase costs, for which we have not yet fully negotiated the cost; they are mostly used when schedule is an issue.)

Regarding the importance of the IFM system to successful procurement operations, we are pleased to report that we are implementing the system according to plan in a phased manner across the NASA centers and expect the process to be complete in June 2003. More details on implementation are in the President's Management Agenda section on Financial Management, Steps to Green 1a through 1e. We are also happy to report that we have reduced the dollar value of undefinitized change orders by 98 percent, from $515 million in September 2001 to $9 million as of September 30, 2002. The Station contract has only one undefinitized change order; its dollar value is $1 million. The OIG is also currently reviewing our undefinitized contract actions. In discussions with us on this matter, OIG indicated they expect their findings to confirm that NASA has made significant progress in this area.

There is also a human capital challenge specifically related to procurement: as the number of procurement personnel has declined, procurement obligations have remained constant or grown. The challenge is to ensure adequate staffing to perform contracting activities. A different GAO review of the status of Agency efforts

NASA managers focus on staff development

Belinda Arroyo is the team chief of the Mission Management Office Multi-Mission Deep Space Network Allocation and Planning Team, an organization that makes sure that NASA's active space missions are allocated adequate time for using the deep space communications network. In addition to supporting 12 active missions, Arroyo's team is working on another 16 still in development.

"It's a lot of fun to train people and teach them your area of expertise and watch them grow," she says. "This area introduces you to a lot of different areas because you work not only with teams—like the ground data system team or the sequencing team—but you work across organizations like navigation and mission planning," she explains. "I think working in the mission management office is a good base for somebody coming in new to a flight project. It gives you a kind of a global view."

recognized that we are taking steps to address our future workforce needs and developing an overall workforce plan that will include the acquisition workforce. The report had positive findings with no recommendations.

NASA has an estimated 686 employees in the procurement workforce. Both the Goddard and Marshall Space Flight Centers are recruiting new employees into this area, and we expect our Intern Program to enhance the NASA workforce. We also established a procurement training and career-development certification program. It provides our procurement professionals a standardized, consistent, and high-quality training program to facilitate career development and increase knowledge of the changing world of acquisition reform. Its combination of training and operational experience aims to enhance business management skills, judgment, ability to deal with acquisition dilemmas, and interactions with other procurement staff and contractors.

Another major challenge pertains to outsourcing and oversight. NASA is increasingly outsourcing its work. At the same time, we are reducing direct procurement oversight of our prime contractors and subcontractors. Outsourcing carries considerable risks unless the Agency carefully provides for adequate internal controls for such functions and the contractors that perform the services. In the past several years, we have worked to strengthen these internal controls. For example, we instituted a risk-based acquisition management initiative that seeks to integrate risk principles throughout the entire acquisition process. Through this initiative, we will thoroughly consider the implications of programmatic risk when developing an acquisition strategy, selecting sources, choosing contract type, structuring fee incentives, and conducting contractor surveillance.

In addition, we are improving surveillance planning and execution to target more meaningful surveillance to areas of significant risk. On September 13, 2002, we published "Government Quality Assurance Surveillance Plan (QASP) Guidance" (PIC 02-17), and worked with the Office of the Chief Engineer to develop NASA Procedures and Guidelines (NPG) 7121, "Procedures and Guidelines for Surveillance Planning on NASA Programs and Projects"; this document is now undergoing Agency review.

We are moving rapidly to make more use of electronic commerce for procurement, including making purchases using electronic catalogs; the Internet; and purchase, fleet, and travel credit cards. However, this poses its own challenge: ensuring adequate internal controls for such procurements that generally involve fewer paper approvals, less documentation, and less supervision. The IFM deployment (described in detail in the President's Management Agenda section on Financial Management above) will improve internal controls through a central repository of procurement information that gives managers accurate insight into where and how procurement dollars are spent. The system will align data and activities across the entire business process—from initial requirements determination through sourcing, procurement, and asset management. In addition, NASA asked OIG to review our use of Smart Pay purchase cards. Although the audit is not yet complete, preliminary findings indicate that controls for the purchase card program are generally effective.

Between FY 1993 and FY 2000, the percentage of funds available annually for competitive procurement declined from 81 percent to less than 56 percent. This situation is compounded because four NASA contractors account for nearly 60 percent of our contract dollars. Competitive Sourcing is a President's Management Agenda initiative and, because it is included in that section of this report, only a brief mention is needed here. We are addressing this issue by improving the review process for exercising options on existing contracts (both competitive and sole source). Before awarding a follow-on contract or exercising an option, we will conduct market and other reviews to ensure that we are maximizing competition and efficiency. An example of a recent success in this area was a contract at the Langley Research Center to establish a National Institute of Aerospace. This contract and several cooperative agreements had been awarded repeatedly to the same parties for 28 years on a sole-source basis. In February 2002, we issued a NASA Research Announcement open to all universities, nonprofits, and consortia comprised of such entities. As a result, we awarded the contract to a new entity in September 2002.

Another performance issue is to use mechanisms such as Earned Value Management and Performance Incentive Fees to provide incentives for better contractor performance. We implemented numerous mechanisms in FY 2002. For example, we are using the Set Fee Initiative to establish the fee on selected contracts. In this initiative, NASA pre-establishes a fee amount or percentage in the contract solicitation rather than having contractors propose fee amounts. This allows contractors to focus their full attention on the technical merits of their proposal rather than trying to decide how much fee to propose, and allows NASA to ensure that the fee amount is adequate to motivate contractor performance. Another mechanism is Award Term Contracting. NASA will conduct a pilot of this nontraditional method of rewarding contractor performance, in which contractors receive periodic performance evaluations and scores that earn them contract term extensions for excellent performance.

E-Government Initiatives

E-Government, or Government's use of electronic means of doing business, is both a President's Management Agenda initiative and a focus of the OIG. In its February 4, 2002, memorandum to the NASA Administrator, the OIG

identified NASA's development and implementation of e-Government initiatives as one of the Agency's most serious management challenges. The memorandum noted that with the increasing availability of electronic means for interacting with citizens, businesses, and stakeholders, NASA must allocate sufficient resources and management attention to e-Government. The OIG report also emphasized the importance of security and privacy in providing electronic services. We recognize the implications of expanding our existing e-Government products and services and are taking steps to implement adequate security, privacy, and other internal controls.

NASA is committed to optimizing use of electronic government to meet the Congressional mandate to provide for the widest practicable and appropriate dissemination of information concerning our activities and the results thereof. We already disseminate information about our programs, missions, and research results to a variety of user communities through our many Web sites and use Web-enabled services and systems for electronic interactions when appropriate. At the same time, we are careful to ensure security of our electronic offerings. Our specific FY 2002 e-Government activities are described in considerable detail in the President's Management Agenda section and thus will not be repeated here.

We continue to look closely at security and privacy issues when rolling out new e-Government initiatives. For example, we have been a leader in the Federal Government's e-Authentication initiative. E-Authentication pertains to methods to both make sure that an online source or document is indeed what it claims to be and to provide for reliable electronic signature. The initiative will allow citizens to interact with Federal agencies in a trusted environment. We will continue to participate in this and other Federal initiatives to share the Agency's expertise in securely implementing e-Government services.

Our general strategies for future action are outlined in the President's Management Agenda section on Expanding Electronic Government. They address concerns outlined in the February 2002 OIG memorandum regarding security, privacy, and management controls.

Fiscal/Financial Management

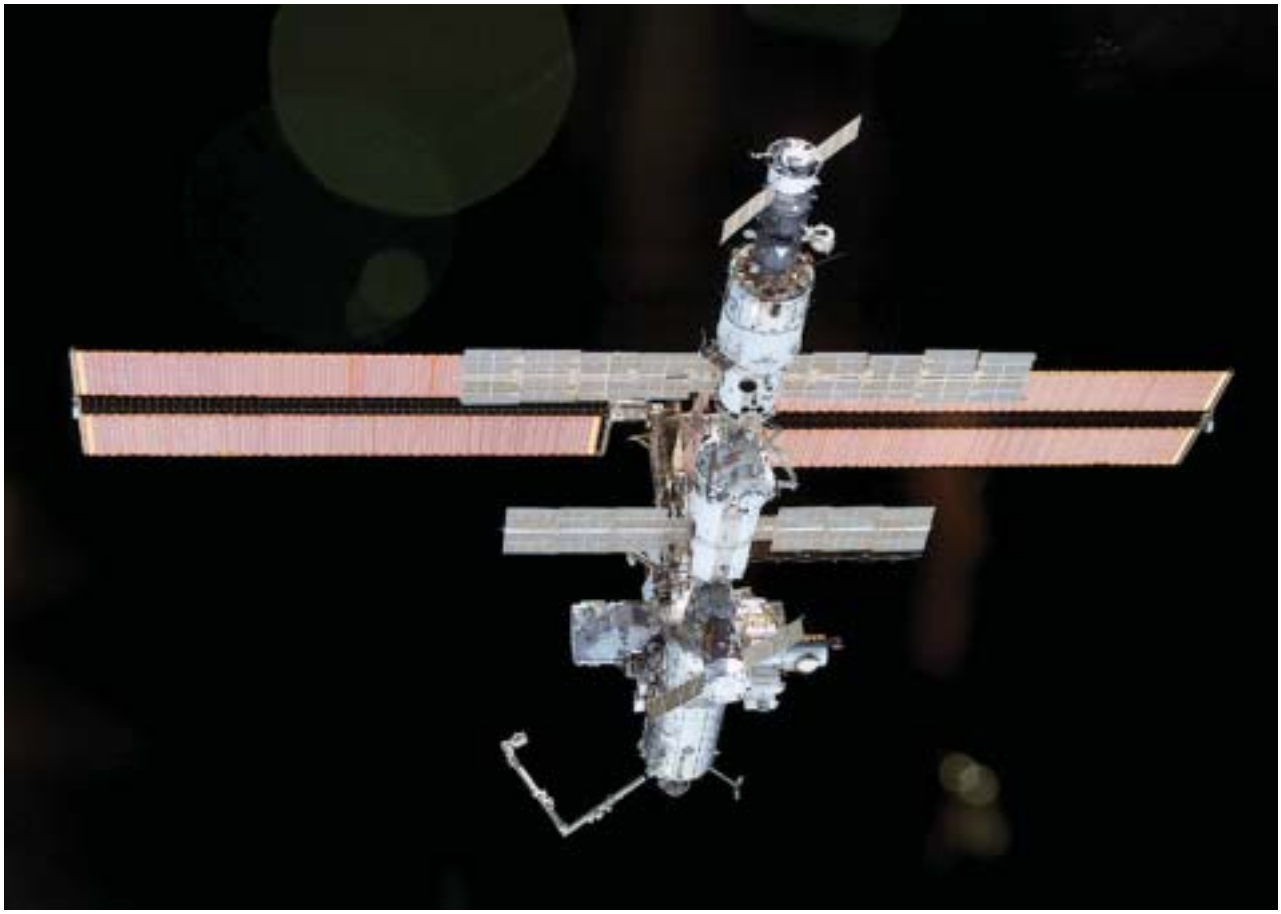
The President's Management Agenda initiative on Financial Management pertains to two areas of interest to the OIG: Fiscal Management and the IFMP.

In October 2000, Congress requested information from the OIG about financial management issues at NASA. The OIG reported problems with obligations (chiefly contracts) management. One of these was ensuring that funds were used for the specific obligations for which they had been appropriated. The OIG noted that fiscal law requires funds approved by Congress to be used for the specific purpose intended by the authorizing legislation, matching disbursements with obligations. NASA had instead employed a first-in, first-out procedure to pay for Agency obligations; this did not require the exact monies authorized by Congress to be used for the specific activity they had approved them for but rather called for making payments using funds that had been available longest before using newly added funds. The OIG also reported that NASA had inadequate controls, especially documentation, for processing deobligations (reducing the dollar amount on contracts).

NASA took issue with the OIG regarding the requirement to match disbursements to obligations, deeming the first-in, first-out practice to be prudent, practical, and legal. The two organizations met in FY 2001 and resolved the issue, collaborating on revising the Financial Management Manual. NASA also agreed to modify the manual to require adequate documentation for deobligation transactions, resolving that issue as well. NASA made the recommended modifications, and the Centers are adhering to the revised procedures. We will conduct periodic evaluations to ensure that the new procedures are followed.

With regard to the IFMP, in 1989 OMB designated NASA's accounting systems as high risk because of obsolescence and lack of standardization. NASA's financial management had relied on many decentralized, nonintegrated systems characterized by Center-unique policies and procedures. In 1995, NASA established the IFMP to plan, coordinate, and manage all aspects of the work necessary to streamline and standardize business processes and to acquire and implement an integrated financial management system solution throughout NASA. The IFMP will improve financial, physical, and human resources management processes throughout the Agency.

Lessons learned from previous efforts coupled with extensive benchmarking of successful business system implementations were the basis for a fundamental restructuring of our approach in March 2000. NASA is now in the midst of successfully implementing the IFM system across all the Centers. This is described in detail in the President's Management Agenda section on Financial Management. The next major step in the IFM will be the budget formulation module, now in detailed design phase at Goddard Space Flight Center. Along with the core financial module, it will provide NASA managers with tools to enable them to implement full-cost management and to consider programmatic decisions, financial impacts, and Center infrastructure together when making decisions. The core financial module will improve NASA's ability to receive and maintain an unqualified audit opinion on our financial statements. When the program is complete, our financial and business system environment will benefit from Agency-wide integrated systems and automated processes producing consistent data in real-time for decision makers.



NASA provides new additions to the International Space Station

This image of the Station was recorded on April 17, 2002, by crewmembers onboard the Space Shuttle Atlantis following the undocking of the two spacecraft some 247 statute miles above the North Atlantic. After more than a week of joint operations between the Shuttle and Station crews, Astronaut Stephen N. Frick, pilot, backed Atlantis away to a distance of about 400 feet in front of the Station, where he began a 1¼-lap fly-around of the Station, newly equipped with the 27,000-pound truss shown here. The S0 truss is the first segment of a truss structure that will ultimately expand the Station to the length of a football field.

Information Technology Security

The GAO report and both OIG letters highlighted information technology security as a subject of concern. The OIG questioned the Agency's safety from unauthorized network access as NASA becomes ever more reliant on cyber-communications. The OIG found NASA's information technology security program to be fragmented, lacking clear lines of authority, policies, guidelines, and enforcement. The letters cited insufficient plans for system-level security and for disaster recovery of mission-critical systems, inadequate technical controls at the host-computer level, lack of an information-technology-security-skilled workforce, and inadequate training.

NASA found that information technology security did not constitute a material weakness: first, we have experienced no perceptible harm to our capital assets or employees. Further, while hostile probes (for example, attempts by hackers to break into NASA's electronic systems) in FY 2001 increased 130 percent, successful penetrations decreased 45 percent. In the same year, the Horn Report ranked NASA third of 24 Executive Branch agencies in information technology security. The National Security Agency characterized NASA's information technology security program as mature, and our Incident Response Center received the Federal Computer Incident Response Center Crystal Eagle Award in August 2000 for responsiveness in incident reporting. However, we still regard information technology security as a significant management concern. We received $20 million in much-needed supplementary funding for improvements in our cyber-antiterrorism posture. We provided information technology security training to 98 percent of all civil service employees and managers and 97 percent of all civil service system administrators, significantly exceeding our training goals.

Information technology security requires long-term attention. We are setting the performance bar higher each year. NASA and OIG will work together to track progress on deficiencies, trends, and projected problems. We established a "One NASA" model for information technology, upgraded and standardized our information

technology security architecture, and reduced system and application vulnerabilities using system security plans and a program to scan systems for vulnerabilities. We have deployed intrusion-detection systems and rapid-response procedures for attempted break-ins and have tested smart cards to control computer and physical access. Recognizing our expertise and dedication, OMB designated us as the technology lead for the Federal Cyber-identity Authentication Program. We are also assisting the Critical Infrastructure Protection Board in developing an Internet operations center to create an early warning system for global network threats. Information technology security training will expand to include mandatory online courses for users, managers, and system administrators. We are also making security planning a key component of computer systems development, incorporating risk management into the planning process. We are now revising and updating the Critical Infrastructure Protection Plan. Strategies for future actions include secure e-mail, smart cards, and secure access control to documents.

International Space Station Program Management and Station Development and Support Costs

Station program management and the Station's development and support costs are other key areas of concern to GAO and OIG. After significant cost growth was identified in early calendar year 2001, the President's FY 2002 Budget Blueprint laid the groundwork for attaining cost control and regaining the credibility the program needs to fulfill its potential.

The top-level success criteria NASA must achieve to restore confidence in its ability to successfully manage Station are safe, successful execution of U.S. Core Complete—the minimum Station configuration—within budget and on schedule; maximum allocation of program resources to research, consistent with operational constraints; and credible requirements, cost estimates, and analyses supporting the potential for expanding research after we achieve U.S. Core Complete. These criteria will demonstrate that the Space Station Program is well managed, research-driven, and affordable.

To this end, the President's FY 2002 Budget Blueprint required an external cost evaluation of the program. Subsequently, an external review team, the International Space Station Management and Cost Evaluation Task Force, was established to perform an independent assessment of cost and budget and to provide recommendations on how to ensure that the Station can provide maximum benefit to researchers, U.S. taxpayers, and our international partners while staying within the Administration's budget request. The task force provided recommendations that have been largely endorsed as a roadmap to improve the Station program management.

In FY 2002, we began executing a new management strategy to achieve high-priority Station objectives within the Administration's and Congress' funding limits. NASA has briefed the approach to the OMB and to Congress. It has five major focus areas (1) The first, most important focus is to prioritize our research plans, which are the foundation for the Station's end-state configuration. (2) The next focus is a detailed, single-minded concentration on building the U.S. Core Complete configuration. (3) We must also implement a reliable, effective, cost estimating and management system with a structured, disciplined DOD-style independent cost-estimating capability supported by a stable set of Station requirements. We took initial actions to improve our cost-estimating capability, institute management efficiencies, and realign staff to maximize accountability and performance. We are also implementing an outstanding management information system. (4) Of great importance is coordinating with our international partners to identify potential growth paths and levels of international involvement. (5) Finally, we must assess mission and research operations as a whole because it is not enough to launch all of the components of the Station and its research, we must also safely operate and sustain them.

NASA is carefully assessing operations to ensure that logistics support is adequate for safety and effectiveness. Even given the positive steps NASA has taken, we understand the need to demonstrate to the Administration and Congress that we can successfully complete our mission within budget before external confidence can be restored. Progress in correcting past management deficiencies is monitored by the NASA Internal Control Council chaired by the NASA Deputy Administrator. Progress will also be evaluated by the Station's Management and Cost Evaluation Task Force on November 13 and 14, 2002. NASA and the OMB are collaborating on success criteria to restore International Spacer Station Program management confidence.

The task force will continue to be involved during the program restructuring, providing subsequent progress evaluations to NASA through the NASA Advisory Council. The evaluations, to be conducted at 1-year intervals from the date of the initial report (November 1, 2001), will contribute significantly to the Administration's estimate of how well we have met the above three success criteria.

Safety and Mission Assurance

Recognizing the importance of safety to NASA's people and mission, OIG has taken a closer look at our Safety and Mission Assurance processes. This detailed scrutiny has identified safety noncompliances at several

NASA Space Shuttles transport crew members and material to the International Space Station

This photo shows the Space Shuttle Atlantis lifting off from the Kennedy Space Center on April 8, 2002. Seven astronauts were en route to the Station for a week of work on the orbital outpost, including the installation of the S0 truss—centerpiece of the station's main truss.

installations. Some of these noncompliances, such as failure to follow established procedures for using plastics, foams, and adhesives, were unknown to management. Others, such as lifting device deficiencies at Stennis Space Center, were originally identified by routine oversight activities and later validated by the OIG. NASA agreed with the majority of the OIG's recommendations, and the Centers that had discrepancies have taken corrective actions. Because of safety concerns related to oversight and compliance, the OIG recommended flagging safety as a management concern and giving it greater attention.

By any measure, NASA has been one of the safest organizations. Our 1999 Agency Safety Initiative was designed to make our already excellent safety program one of the best in the world. Leadership repeatedly emphasized the importance of safety. NASA was the first Federal agency to have one of its activities certified by the Department of Labor's Occupational Safety and Health Administration Voluntary Protection Program (VPP) at the elite STAR level. High-visibility awareness programs abounded. By the end of FY 2001, two of NASA's Centers had achieved STAR VPP recognition and were certified by OSHA as being among the best of the best in safety. In 2000 and 2001, NASA experienced the highest Shuttle flight rate in recent history with no significant in-flight anomalies. Safety performance evaluation profile scores, which measure knowledge and attitudes toward safety, improved among managers and employees. Mishap rates declined. The lost-time case rate, which measures the more serious worker injuries, fell from 0.54 in FY 1998 to 0.31 in FY 2001.

In 2002, the Senate unanimously confirmed the former Associate Administrator for Safety and Mission Assurance as NASA's Deputy Administrator, placing a strong safety advocate at the very highest level of operational decision-making. Three more NASA activities achieved VPP STAR status. NASA's lost-time case rate fell to 0.25—less than half of its already low FY 1998 level. Other Federal agencies and private sector companies look to NASA as a trailblazer in moving safety from being seen as a sometimes-bothersome requirement to an internalized value that is indeed a part of all operations and decisions.

Although there are still occasional noncompliances at NASA, they are far fewer than is generally expected in such a large organization. Having OIG, NASA Headquarters, local inspectors, and third-party evaluators constantly on the lookout for such instances further increases the likelihood that they will be found and fixed before harm occurs. This constant watchfulness is fundamental to mishap prevention strategy and is a management strength. Our significant reduction in mishap rates confirms this: NASA's total case rate of all injuries stands at 0.84—far below the eventual FY 2005 Presidential goal of 1.12 established under the Federal Worker 2000 five-year safety campaign.

An organization can never simply check safety off a to-do list and label the action complete. A successful safety effort must be constantly nurtured. NASA will continue its high-performing safety practices. Using an array of risk assessment and management processes combined with a deep-rooted belief in management commitment and employee involvement, NASA is determined to continue progress toward its long-term goal of zero mishaps.

Launch Vehicles

Launch vehicles are a continuing concern for OIG. In both of its reports, it recommended that NASA develop a pricing policy for Shuttle payloads. The OIG found that charges to outside agencies and organizations appeared arbitrary and inconsistent and failed to conform to

statutory requirements, possibly resulting in significant undercharges. NASA has taken issue with this finding, questioning whether the report correctly interprets pertinent statutes and their applicability to Shuttle mission development. Debate between NASA and OIG continued for some time in FY 2002, resolving some questions but not all of them. At the end of FY 2002, our two organizations met to discuss the outstanding recommendations. At the meeting, NASA's Audit Followup Official directed them to meet further to discuss these recommendations and return with a final position. A follow-up meeting is scheduled for the first weeks of FY 2003. It is likely that changes in Agency-wide financial management will result in a new Agency policy that can better address Shuttle pricing.

With regard to key follow-up on a past audit, "Follow-up on Audit of Orbiter Maintenance Down Periods," the NASA Administrator announced in early February 2002 that future Orbiter Major Modifications would be performed at Kennedy Space Center. We began these modifications on the Shuttle Discovery at the close of FY 2002. The following is a summary of findings and recommendations of related Shuttle evaluations completed in FY 2002.

A RAND Corporation business review identified seven potential business models/options for Space Shuttle Program competitive sourcing. Those options are under review and we anticipate a decision on a course of action in February 2003. A Headquarters-initiated special cost-benefit assessment of the Checkout and Launch Control System provided an estimate of costs and the likely date the system would be launch-capable. Based on the results, this assessment recommended canceling the system. NASA approved the cancellation; we will redirect efforts toward supporting and enhancing the existing Launch Processing System, which continues to meet ongoing Shuttle requirements. This demonstrated the ability of the new cost-estimating function to detect and prevent an investment not in NASA's best interest as a prudent program manager. A Cockpit Avionics Upgrade independent cost estimate was conducted this summer; the estimate agreed closely with the current NASA funding profile. In addition, the Independent Program Assessment Office conducted a Cockpit Avionics Upgrade non-advocate review in FY 2002. It found that the project has made considerable progress in hardware design and system and software requirements. While the contractor project management team has been strengthened and technical findings/issues from the previous review have all been resolved, there is still concern with the contractor's delivery schedule.

Security of NASA Facilities and Technology

In August 2001, NASA raised the profile of issues pertaining to security of NASA facilities and technology by establishing the Office of Security Management and Safeguards under the direction of an Assistant Administrator reporting directly to the NASA Administrator. Also in FY 2002, NASA requested and received additional funding for much-needed security enhancements as well as an augmentation of 35 full-time civil servants to the security staff. We created policies and standards to ensure uniform procedures for granting and controlling access to NASA facilities, technology, and information. This has increased the breadth and depth of security at NASA, providing necessary tools to defend the Agency's personnel, facilities, assets, information, and programs.

In response to heightened security requirements following the events of September 11, 2001, Congress appropriated security enhancements (human resources, physical/technical countermeasures) and funds for information technology (computer) security requirements. This enabled NASA to make essential security enhancements across all 10 NASA Centers, reducing the Centers' vulnerability to security threats. In addition to increasing physical and information technology security, NASA instituted centralized critical security functions, a more vigorous counterintelligence and counterterrorism program, stricter policies on access procedures and controls, and stronger relationships between security entities and NASA programs that affect security. We have implemented a security and counterterrorism awareness program that leverages daily law enforcement and intelligence community threat information to further minimize potential vulnerabilities and threats to NASA's workforce, mission, and assets.

Cost Estimating

During the 1996 reorganization of NASA and the associated downsizing of the workforce, especially at NASA Headquarters, the Agency lost a notable portion of its independent cost estimating capability. The situation was compounded by pressures put upon the remaining cost estimating community to estimate missions in the "faster, better, cheaper" mode. This mode saved money and brought about efficiencies, but it also ran a real risk of severely underestimating requirements. As a result, NASA suffered through significant and demoralizing cost overruns on several of the faster, better, cheaper missions. Various outside observers including the OIG, the GAO, the OMB, and others appropriately criticized these outcomes. NASA management recognized that its cost analysis capability had eroded and undertook corrective measures.

During 1999 and 2000, we had established System Management Offices at each NASA Center, incorporating the cost estimating function. The offices were valuable for two reasons: One, they afforded some measure of independence for cost estimating because they reported directly to the Center directors, not through the project office advocacy chain of command. Second, the offices

generally included a systems analysis capability along with cost estimating. The systems analysis helped ensure that a project's requirements had been properly established and that the design validly met the requirements. In addition to establishing the offices, we clearly delineated in NPG 7120.5A, "Program and Project Management," and many other procedural instructions, the importance of independent cost estimating as a key part of the overall project-management process. These actions led to the beginnings of a renewal of the cost analysis discipline within NASA.

FY 2002 has seen the advent of what many NASA cost estimators have referred to as a new age in NASA cost analysis. The new management team at NASA has dramatically communicated its interest in and support of expert, professional cost estimating within the Agency. The number of cost analysis positions in the Agency is dramatically rising at every Center: 102 positions were made available in FY 2002 and 2003. These positions are at higher grade levels than were available before. Budget resources for cost estimating tools and methodologies are being provided at levels sufficient to fund needed improvements. Today, NASA cost analysts are viewed, more than ever, as a valuable part of each product development team. Their work is highly valued as a critical parameter in defining cost-effective missions.

Several more specific improvements bear mentioning. On the International Space Station, we completed a major independent cost estimate that formed the basis for the cost reserves needed over the next 5 years to ensure that the program is on a sound financial footing for the first time in its history. Independent cost estimates were applied to several other projects, which led to either their termination before unacceptable cost growth or their redesign to more cost-effective configurations. For example, NASA cancelled a project to revise Shuttle launch software because of unacceptable cost growth. Instead, we are substantially modifying the existing launch software system to support the Shuttle until a new transportation vehicle is operational. While such cancellations are regrettable, they send a clear signal that NASA means business about getting its financial house in order. A new cost analysis division at NASA Headquarters has been established to act as gatekeeper for all NASA cost estimates before they go forward in the budget. This office also will establish overall strategic direction for NASA's cost analysis processes. This division is structured to cooperate closely with other new organizations at Headquarters working to correct NASA program management deficiencies. The Independent Program Assessment Office at Langley Research Center has been administratively reassigned to Headquarters to strengthen its synergy with these efforts. We have totally revised our financial management information systems. (See the previous discussion of the new IFMP in the Financial Management President's Management Agenda section of this report.) The new systems are designed to provide better and more real-time financial information and to cast the data in terms of full cost accounting practices so that for the first time we really know the total cost of NASA projects. We are revising and improving our criteria for conducting independent reviews. We will have new procedures defined by early FY 2003 and ready to incorporate in revisions to our documented management instructions. We are completing a study on the possibilities of privatizing the Shuttle and are adopting the cost-benefit and risk analysis approaches used in that study to other key NASA decision-making processes.

Our plans include vigorous, continuous improvement in cost analysis. We are re-energized to provide the very best cost work possible. We are on track for recruiting the best and brightest talent for this exciting and challenging discipline. We have improved cost- and financial-analysis tools. While we recognize that cutting-edge research and development activities will always be a tough estimating challenge, the NASA cost-estimating community is united in its determination to bring its performance and credibility to exemplary levels.

Environmental Management/National Environmental Policy Act Implementation

The National Environmental Policy Act (NEPA) is the national charter that established environmental goals and policies to protect, maintain, and enhance the environment. The act mandates that all Federal agencies consider the effects of their actions on the environment as early as possible in the planning process and requires agencies to (1) gather information about environmental consequences, (2) consider environmental impacts when making decisions, (3) consider alternatives that avoid or reduce adverse impacts, and (4) keep the public informed. The act requires that NASA integrate environmental quality with our primary mission and integrate environmental review milestones with major NASA decision points.

In a March 2000 audit, OIG recommended strengthening management controls to ensure greater visibility and more consistent implementation of the act and made specific recommendations, several with multiple components. The recommendations generally related to (1) expediting update of NASA procedures and guidance for implementing NEPA, (2) integrating act requirements and status checks into decision-making processes, (3) correcting deficiencies in 13 specific programs and projects, and (4) implementing act training for managers. The OIG found that the deficiencies noted during the audit could delay, diminish, or preclude missions and related facilities projects. They also could result in NASA having to shift scarce staff resources and budget in order to complete consultation with other agencies and respond to public controversy, heightened Congressional interest, and litigation. The OIG noted compliance with the act as

a continuing area of management concern in both its December 2000 and its February 2002 letters.

In response to OIG recommendations, NASA initiated rulemaking in FY 2001 to update its act implementation procedures, issued revised guidance, and integrated act requirements into the Non-Advocate Review process, Program Management Council reviews, and other ancillary guidance. In FY 2002, NASA finished correcting deficiencies in act compliance for the projects identified by OIG and provided training to program and project offices at several Centers and at Headquarters. NASA added a module to its NASA Environmental Tracking System to track the status of compliance and associated documents for programs and projects that trigger an Environmental Assessment or Environmental Impact Statement. Additionally, NASA has asked the academic grants, budget, and facilities offices and each Enterprise to provide an annual list of planned programs and projects and to designate a NEPA document manager for each proposal. NASA is recommending that compliance with the act remain on the list of management concerns until the updated "Program and Project Management Guide," NPG 7120, is published. NASA has amended Center Environmental Function reviews to include a review of act compliance. Training for program and project offices at all Centers will be completed in FY 2003.

Plum Brook Reactor Decommissioning

The Plum Brook Reactor Facility comprises about 27 acres at NASA's Plum Brook Station near Sandusky, OH. The facility contains a 60-megawatt thermal materials testing and research reactor, a 100-kilowatt mock-up reactor, and other facilities that supported the reactors. Although the reactors are no longer active, the Nuclear Regulatory Commission has determined that it will not reissue NASA's "possess but do not operate" license. This decision effectively mandates that we decommission the facility.

Decommissioning the Plum Brook Reactor Facility is a significant area of concern for NASA. The OIG also noted the problems in its second letter (February 2000) on management issues. Under Nuclear Regulatory Commission regulations, NASA is terminating its license through decommissioning by 2007. Decommissioning the nuclear reactors is one of NASA's highest environmental priorities. The complex planning and execution involve multiple organizations and authorities in both the public and private sectors. Further, the only identified radioactive waste disposal site we can use in this effort closes in 2008.

In FY 2001, the reactor decommissioning team consisting of NASA, the U.S. Army Corps of Engineers, Argonne National Laboratories, and several nuclear facility demolition and disposal contractors was put in place. The team completed the plans and forwarded a decommissioning plan to the Nuclear Regulatory Commission for approval. The commission approved NASA's decommissioning plan on March 20, 2002. Funding necessary to complete this project is part of NASA's 5-year plan, although future funding is contingent on budget and appropriation approvals. The decommissioning project is now entering the implementation phase, with the reactor vessel planned for segmentation in January 2003. As a result, NASA contemplates removing Plum Brook from the management concern area at the next Internal Control Council meeting in early FY 2003.

Effectiveness of Faster, Better, Cheaper

The GAO report raised questions about the effectiveness of the faster, better, cheaper approach for space exploration. The concept of faster, better, cheaper traces its roots to the late 1980s and reflects a strategy to improve performance by streamlining engineering and management practices. At NASA, this theme coincided with a trend to develop smaller spacecraft needed to perform more focused research in the wake of discoveries made by large, facility-class instruments. The philosophy also spread within NASA to encompass other programs and projects, becoming an Agency-wide strategy of process improvement. Faster, better, cheaper as an engineering and management philosophy is slightly more than a decade old now, enough time to evaluate the success of the new practices that have been put in place within NASA and the contractor community.

Overall, the philosophy has led to some important innovations. NASA and other Government organizations have developed numerous new spacecraft that are demonstrably less expensive than their predecessors. Underpinning the faster, better, cheaper philosophy was a goal to speed the development and infusion of new, high performance technology. This allows a smaller spacecraft to return impressive amounts of scientific data. The Mars Pathfinder spacecraft was an example of a very successful Discovery-class mission that both demonstrated new technology and returned valuable scientific data. The pace of developing ever-more-capable spacecraft is accelerating and NASA looks forward to new generations of spacecraft with improving capabilities.

NASA has encountered some problems with the implementation of faster, better, cheaper and we are working hard to correct them. As GAO correctly points out, it is in the area of reliability that the shift to faster, better, cheaper has caused the greatest concern; this can be traced to three key reasons. First, faster, better, cheaper resulted in smaller spacecraft and more numerous missions. This meant that we needed more managers and, importantly, more reviewers to provide oversight of spacecraft development projects. NASA also reached outside of the Agency, placing university-based principal investigators in charge of projects. This required an unprecedented

level of integrated project management that took a good deal of time to perfect. The second reason for a decline in reliability was the setting of overly aggressive cost targets. Initial success with cost-saving initiatives led to further reductions that resulted in unacceptable risk being taken with individual projects. In short, faster, better, cheaper led to unrealistic cost targets and a reduction in the test and quality measurement efforts needed to assure success. In a related fashion, the third reason for lowered reliability was traced to risk management practices that were not symmetric across the Agency. This resulted in insufficient attention being paid at critical junctures in the development of some projects.

In FY 2002, NASA reviewed the lessons learned from the faster, better, cheaper philosophy and began a process of culling the positive attributes of the philosophy and incorporating them in Agency practices. A great deal has been written about the effect of faster, better, cheaper and these various resources were reviewed and incorporated in Agency planning. Based on careful assessment, faster, better, cheaper is no longer being espoused as a NASA engineering and management philosophy. NASA is committed to the development of spacecraft that demonstrate higher levels of performance, greater reliability, and lower development costs. These three goals are not impossible to achieve simultaneously—they are a reflection of a commitment to constant product improvement. At the heart of the faster, better, cheaper philosophy was a commitment to constant innovation and the need to extract the best possible performance from available funds. NASA will retain this commitment while balancing it with a prudent assessment of risk. Throughout the Agency, engineers, and scientists will continue to find new ways to stretch resources to achieve challenging mission objectives without a loss of product quality.

Space exploration will always involve risk. As an exploration Agency, we expect to experience failure as we develop unprecedented spacecraft and send them to unexplored and hostile environments. NASA does not accept, however, losses that reflect poor product quality. To ensure the highest quality standards, we have set about revamping our management and engineering practices to incorporate the lessons we have learned. Specifically, we intend to instill greater uniformity in managing risk and to codify these practices Agency-wide. The Agency is revising official guidelines for program and project management to include the lessons learned from faster, better, cheaper activities. We have also begun to relate carefully cost targets to the complexity of the mission under development and the level of risk deemed acceptable to Agency leadership. To relate those decisions to the policymaker, NASA's managers are preparing techniques for communicating Agency investments in a portfolio plan. We are also strengthening our ability to perform independent assessments of Agency programs and projects. In the future, we expect to be able to communicate more effectively the scientific and technical performance we expect to return, as well as how funds are risks are spread across the broad spectrum of aerospace programs and projects.

In summary, faster, better, cheaper was an experiment in management and engineering that made important contributions. It opened the door to a new generation of spacecraft and the proliferation of missions from which we expect a rich harvest. As a significant departure from previous practices, the faster, better, cheaper philosophy has led to the need for refinement in the way we manage and build aerospace systems. The result will be stronger business methods that NASA expects will yield an array of higher performance and higher quality systems.

The remaining three management areas were discussed in OIG's December 2000 letter but not in its February 2002 letter, reflecting the significant progress NASA had made by the middle of FY 2002.

International Agreements

With regard to International Agreements, in its December 2000 letter to the Congress regarding NASA management challenges, the OIG discussed concerns and recommendations it had stated in previous reports and management letters regarding foreign national access to technology and facilities. NASA has addressed and implemented each of those recommendations over the past 2 years.

The OIG recommended that NASA include guidance in either a NASA Federal Acquisition Regulations Supplement amendment, Procurement Information Circular, or NPG document. The guidance recommended that all appropriate NASA contracts require the contractors to deliver (1) a plan for obtaining any required export licenses to fulfill contract requirements, (2) a listing of the contractor licenses obtained, and (3) a periodic report of the exports effected against those licenses. The OIG also recommended that NASA revise its policy to incorporate the oversight responsibilities of appropriate NASA officials for those cases in which NASA or its contractors obtain export licenses on behalf of a NASA program. In February 2000, NASA issued a Federal Acquisition Regulations supplement notice with general export control guidance to contractors, and in September 2002, we issued a Procurement Information Circular. With these two issuances, we met the OIG's specific requirement. Most recently, in October 2002, NASA provided the OIG the draft of a new comprehensive document, NPG 2190 for the NASA Export Control Program, providing guidance, instructions, and responsibilities for NASA employees engaged in NASA activities involving the transfer of commodities, software, or technologies to foreign individuals or organizations.

The procedures and guidelines document contains several contractor oversight provisions. For example, it requires NASA program and project managers to oversee

NASA-directed contractor export activities, including the appropriate use of license exemptions/exceptions; requires use of NASA-obtained licenses; and requires contractors to provide NASA with copies of relevant export records. In addition, it requires auditors to determine whether contractors using NASA-obtained export licenses or exporting at NASA's direction are complying with the relevant regulations and record-keeping requirements. The draft document is now undergoing Agency review and approval.

With regard to a specific contractor, the OIG recommended that Boeing establish an export control program and a detailed, company-wide export policy to comply with applicable laws and regulations before using NASA-obtained export licenses for the Space Station Program. The report also recommended that NASA periodically review Boeing's and its subcontractors' export control programs to ensure that when they effect exports using NASA-obtained licenses in support of the Space Station Program they do so in accordance with applicable U.S. export laws and regulations. In response, Boeing provided a company-wide export control manual, which export control officials at the Johnson Space Center, the Center with lead responsibility for the program, reviewed. NASA Headquarters export control officials reviewed a copy of Boeing's Export-Import Compliance Manual, signed by Boeing's Vice President of Export Management and Compliance. NASA export control officials provided guidelines to the Station program manager at the Johnson Space Center in May 2001 about use of the International Space Station Special Comprehensive export license by both NASA and its contractors. We also note that the NASA Export Administrator issues direction memoranda for each use of NASA-obtained export licenses and requires reports on all NASA and contractor exports that use those licenses.

The OIG also recommended methods of reviewing and managing foreign national visitors to NASA facilities. First, the OIG recommended revising the definition of foreign national in our policy guidance, and revising existing policy to establish Agency-wide requirements and procedures for obtaining National Agency Checks. In response, NASA revised the Agency procedures and guidelines document, NPG 1371.2, to define foreign national as anyone who is not a U.S. citizen, consistent with NASA's security procedures and guidelines. The revised procedures and guidelines also clarify National Agency Check requirements for background investigations of foreign nationals visiting NASA facilities. An Agency review is underway for this revised document.

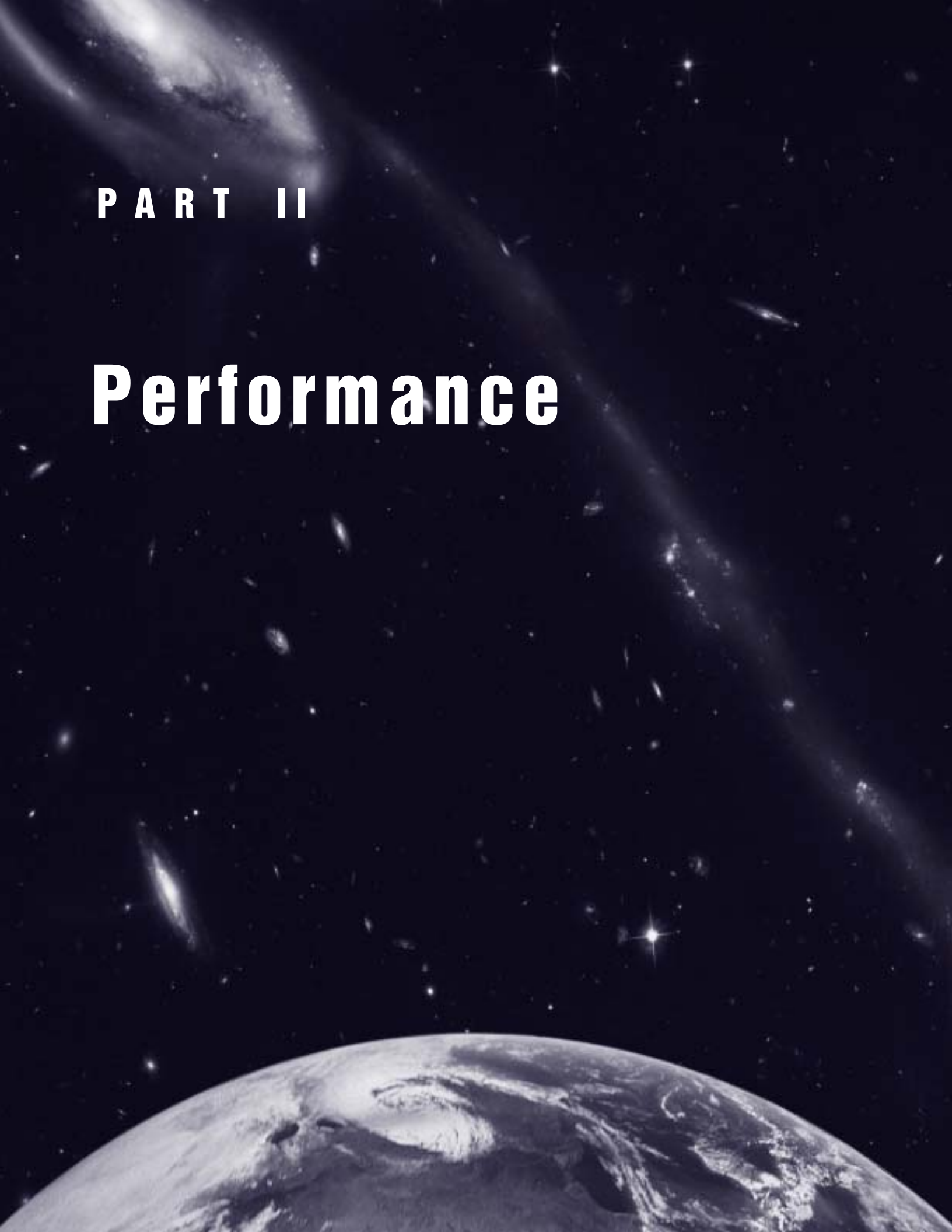
The OIG also recommended that NASA develop and implement an Agency-wide management information system to support the our foreign national visitor program. NASA implemented the Foreign National Management System in September 2000. All NASA facilities use the system to input, track, review, and approve all access by foreign nationals to any of our facilities.

NASA space technology is used to protect people on Earth from anthrax

A technician at KES Science & Technology Inc., in Kennesaw, GA, assembles the AiroCideTiO2, an anthrax-killing device about the size of a small coffee table. The research enabling the invention started at one of 17 NASA commercial space centers—the Wisconsin Center for Space Automation and Robotics at the University of Wisconsin-Madison. A special coating technology used in the anthrax-killing invention is also being used inside plant growth units on the International Space Station.

Technology Development

The December 2000 OIG report reviewed NASA's technology development. The report stated that while NASA's emphasis on technology transfer has varied over time and we have a long tradition of technology development, our recent focus on the Shuttle, the Station, and large, low-risk science missions resulted in the relatively few new space technologies. The OIG has become interested in this because of certain technology-related organizational changes at NASA, such as the cancellation of the High-Speed Civil Transport, the start of the Station era (opening an opportunity for increased in-space research and technology development), and the consolidation of the commercial aircraft industry. The OIG said that future reviews of NASA technology development would address themes related to these items. However, the OIG issued no specific recommendations.



PART II

Performance

Summary of Annual Performance by Strategic Goals

Enterprise Strategic Goals	Annual Performance Goals: Percent Achieved	Annual Performance Goals: Percent Not Achieved
Space Science		
Goal 1. Science: chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life	100	0
Goal 2. Technology/Long-Term Future Investments: develop new technologies to enable innovative and less expensive research and flight missions	100	0
Goal 3. Education and Public Outreach: share the excitement and knowledge generated by scientific discovery and improve science education	100	0
Earth Science		
Goal 1. Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth	91	9
Goal 2. Expand and accelerate the realization of economic and societal benefits from Earth science information and technology	100	0
Goal 3. Develop and adopt advanced technologies to enable mission success and serve national priorities	71	29
Biological and Physical Research		
Goal 1. Conduct research to enable safe and productive human habitation of space	100	0
Goal 2. Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology	100	0
Goal 3. Enable and promote commercial research in space	100	0
Goal 4. Use space research opportunities to improve academic achievement and the quality of life	100	0
Human Exploration and Development of Space		
Goal 1. Explore the space frontier	100	0
Goal 2. Enable humans to live and work permanently in space	90	10
Goal 3. Enable the commercial development of space	100	0
Goal 4. Share the experience and benefits of discovery	50	50
Aerospace Technology		
Goal 1. Revolutionize Aviation—Enable the safe, environmentally friendly expansion of aviation	100	0
Goal 2. Advance Space Transportation—Create a safe, affordable highway through the air and into space	100	0
Goal 3. Pioneer Technology Innovation—Enable a revolution in aerospace systems	100	0
Goal 4. Commercialize Technology—Extend the commercial application of NASA technology for economic benefit and improved quality of life	100	0
Goal 5. Space Transportation Management—Provide commercial industry with the opportunity to meet NASA's future launch needs, including human access to space, with new launch vehicles that promise to dramatically reduce cost and improve safety and reliability. (Supports all objectives under the Advance Space Transportation Goal)	100	0
Crosscutting Process Strategic Goals		
Manage Strategically. Enable the Agency to carry out its responsibilities effectively, efficiently, and safely through sound management decisions and practices	70	30
Provide Aerospace Products and Capabilities. Enable NASA's Strategic Enterprises and their Centers to deliver products and services to customers more effectively and efficiently	67	33
Generate Knowledge. Extend the boundaries of knowledge of science and engineering to capture new knowledge in useful and transferable media, and to share new knowledge with customers	100	0
Communicate Knowledge. Ensure that NASA's customers receive information from the Agency's efforts in a timely and useful form	75	25

Performance Discussion

Space Science

MISSION: Discover how the universe began and evolved, how we got here, where we are going, and whether we are alone

PERFORMANCE

NASA's space science effort seeks to chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planetary bodies, and life. We ask basic questions that have eternally perplexed human beings: How did the universe begin and evolve? How did we get here? Where are we going? Are we alone? The cumulative performance of our flight programs and basic research allow us to achieve annual performance goals that lead to progress toward our long-term objectives. The findings from space probes, robotic explorers, observatories, and computer modeling strengthen our quest to answer questions that explain our past and that may shape our future.

Strategic Goal 1. Science: chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life

Space science had a very successful year in pursuit of this strategic goal. We achieved 100 percent of our performance measures. However, we cannot provide trend data for specific measures because we restructured the way we measure performance. Many of our former performance measures did not represent the scientific outcomes of our programs; instead, they related to technology and flight program development. Although we continue to measure important development activities, most of the rewards from what we do, and the associated benefits to society, are in our science outcomes. Consequently, we revised our performance measures, incorporating advice from the NASA Advisory Committee.

Strategic Objective 1. Understand the structure of the universe, from its earliest beginnings to its ultimate fate

Achievements. The research supporting this objective seeks to (1) identify dark matter and learn how it shapes galaxies and systems of galaxies and (2) determine the universe's size, shape, age, and energy content.

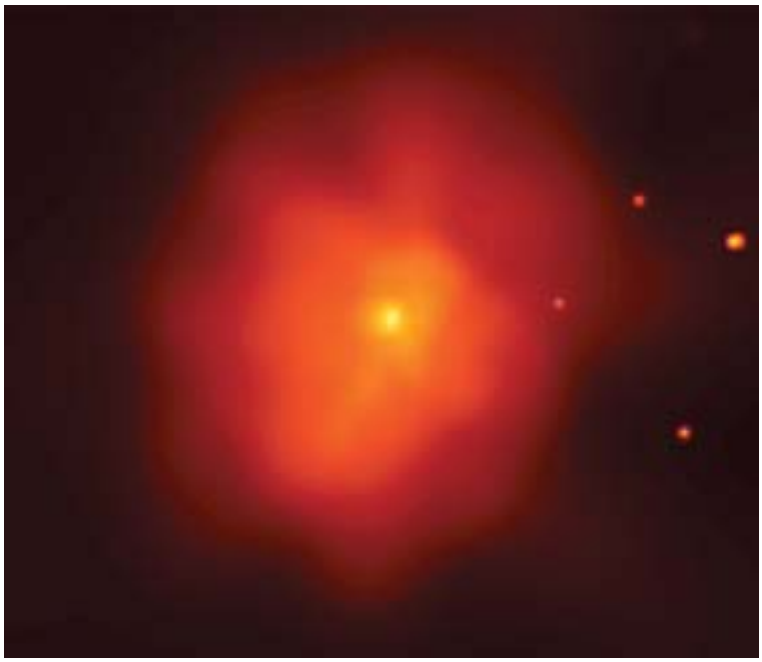
Critical observations in the search for dark matter were made at NASA's observatories. The Chandra X-ray Observatory instruments provided NASA with views of an elliptical galaxy and offered the most detailed measurements to date of the dark matter distribution, thereby eliminating the entire class of self-interacting dark matter theories. Chandra observations of the Virgo cluster of galaxies showed that dark matter is not composed of massive neutrinos. The Hubble Space Telescope measured the amount of dark matter in several target galaxies by using them as gravitational lenses and observing light from more distant galaxies that has been focused by the dark matter in the target galaxies. Hubble observed a dark matter object directly for the first time thereby showing that a fraction of dark matter is composed of small, faint stars.

The Microwave Anisotropy Probe became the first spacecraft stationed at the Sun-Earth Lagrange 2 point—a position where gravitational forces of the Earth and Sun nearly cancel each other—when it began operations in October 2001. In April 2002, the spacecraft completed the first of eight planned all-sky maps of the cosmic microwave background, the most sensitive to date. Scientists will use the data to determine the basic parameters of the physical universe, such as size, shape, matter (including the dark matter) content, and energy content, and to determine when the first stars in the universe formed.

Challenges. Dark matter does not emit electromagnetic radiation; therefore, we detect it only indirectly through its influence on its surroundings. It requires extraordinarily capable observatories such as the Chandra X-ray Observatory and the Hubble Space Telescope to measure dark matter's subtle influences. To unravel dark matter's influence on the evolution of galaxies and the universe's structure, these observatories must be able to detect the signature of dark matter across the entire universe. Frequently, we advance our scientific understanding by combining NASA's space-based data with data from the largest and most sophisticated ground-based observatories.

Over two-thirds of the content of the universe was unknown as recently as 1998. The discovery of evidence for dark energy in 1998, using data from the Hubble and the most powerful ground-based telescopes, has led to a new paradigm in cosmology. We now believe that a dark energy dominates the universe and creates a pressure force in the vacuum of space that causes space itself to grow at an accelerating pace. Within the last few billion years, this mysterious dark energy has overpowered the mutually attractive gravitational force of all the matter in the universe, and the expansion of the universe that began in the Big Bang is now accelerating (rather than decelerating, as we believed just a few years ago). Only with more sensitive measurements will we be able to further improve our knowledge of the geometry and contents of the universe.

Plans. Chandra and Hubble observations will further define the nature and influence of dark matter. The Microwave Anisotropy Probe will complete analysis of its



NASA learns more about what dark matter isn't

Scientists say that about 90 percent of the matter in the universe is in some dark, as-yet undetected form that makes its presence felt only through gravity. All matter, by virtue of its mass, exerts a gravitational attraction. Dark matter seems to be the gravitational glue holding together galaxies and galaxy clusters, for neither type of cosmic structure has enough visible mass to keep it from flying apart.

Using this image of a cluster of galaxies in the Draco constellation, scientists determined that the dark mass in the cluster is about four times that of normal matter. This implies that dark matter is highly concentrated and is not noticeably self-interacting. That is, particles of dark matter are not likely to collide with one another like billiard balls and "puff out" or become diffuse throughout the galaxy. According to Dr. Michael Lowenstein of NASA's Goddard Space Flight Center, "We still don't know what dark matter is, but we now have a much better idea of what it isn't."

first of eight planned all-sky map and determine the size, shape, age, and energy content of the universe to better precision than ever before. Development will continue on future missions to make possible measurements never before available. These include the James Webb Space Telescope and the European Space Agency's Planck mission. Studies will be undertaken to identify space science investigations that can determine the nature of dark energy and what powered the Big Bang.

Strategic Objective 2. Explore the ultimate limits of gravity and energy in the universe

Achievements. The research supporting this objective seeks to (1) discover the sources of gamma-ray bursts and high energy cosmic rays, (2) test the general theory of relativity near black holes and in the early universe and search for new physical laws using the universe as a laboratory, and (3) reveal the nature of cosmic jets and relativistic flows. The following descriptions are highlights of this year's accomplishments.

Scientists captured the optical afterglow of a gamma-ray burst just 9 minutes after the explosion, a result of precision coordination and fast mobilization of ground-based telescopes upon detection of the burst by NASA's High-Energy Transient Explorer–2 satellite. This satellite, a United States collaboration with France and Japan, is the first satellite dedicated to the study of gamma-ray bursts. The satellite's quick detection allowed scientists to determine a minimum distance between the Earth and the explosion, which has probably created a black hole. Results poured in as 100 telescopes in 11 countries tracked the burst.

Using a NASA instrument on the European Space Agency's XMM-Newton satellite, an international team of scientists saw energy extracted from a black hole for the first time. Using Chandra and XMM-Newton, scientists have found new evidence that light emanating from near a black hole loses energy as it climbs out of the black hole's gravitational well. This finding confirms a key prediction of Einstein's theory of general relativity. The observation also may explain the origin of particle jets in quasars.

The Trans-Iron Galactic Element Recorder scientific balloon experiment set a new flight record of almost 32 days after completing two circuits of the South Pole. It searched for the origin of cosmic rays, atomic particles that travel through the galaxy at near light speeds and shower the Earth constantly.

Challenges. In order to make progress in achieving this strategic objective, scientists must devise innovative ways of using the universe as a laboratory. However, unlike laboratory experiments on Earth, the observers have no control over the experiment; they are limited to the activities that are taking place in the universe. One of the most difficult challenges is searching through the large number of potential targets in the sky (for example, galaxies) to find one appropriate for investigating the ultimate limits of energy and gravity in the universe (for example, a galaxy with a supermassive black hole that is losing rotational energy).

A second challenge is very remote sensing. Since scientists cannot weigh a distant black hole on a scale or measure its distance with a tape measure, they must be increasingly creative in squeezing every bit of information from the light that cosmic sources emit. Detecting the distant sources with sufficient sensitivity requires that telescopes have larger collecting areas and highly efficient detectors.

Plans. We will continue to use our great observatories, Hubble and Chandra, to study the extremes of nature. We will supplement them with specialized smaller observatories, including the Rossi X-ray Timing Explorer and the Far

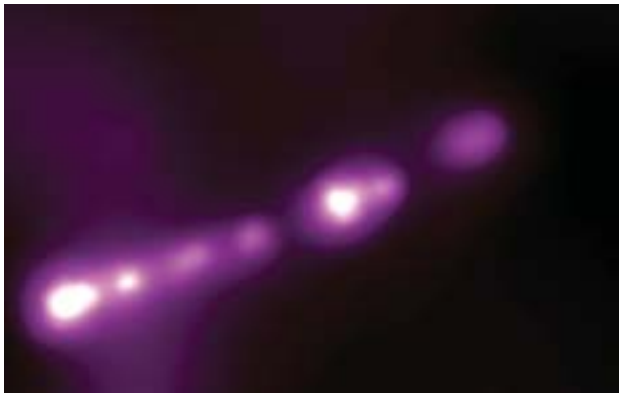
Ultraviolet Spectroscopic Explorer. Gravity Probe-B will begin its mission to directly detect the dragging of space-time by a rotating body (the Earth). Development will continue on the Gamma-Ray Large Area Space Telescope.

Strategic Objective 3. Learn how galaxies, stars, and planets form, interact, and evolve

Achievements. The research supporting this objective seeks to (1) observe galaxy formation and determine gravity's role in the process; (2) establish how a galaxy's evolution and stars' life cycles influence which chemicals are available for making stars, planets, and living organisms; (3) observe the formation of planetary systems and characterize their properties; and (4) use the exotic environments in our solar system as natural science laboratories and cross the solar system's outer boundary to explore the nearby environment of our galaxy. The following are highlights of this year's accomplishments:

Early in the cosmos, the star formation rate may have been more intense than we have until now suspected and may have peaked less than 1 billion years after the Big Bang. This conclusion, based on Hubble Space Telescope images, helps astronomers understand how the earliest galaxies may have assembled. More and more astronomers recognize that mergers play a major role in building galaxies: Hubble observations of very bright infrared galaxies have shown that most of them harbor double, multiple, or complex nuclei, likely evidence of mergers.

The large-scale structure of the universe forms a ghostly, pervasive web of helium gas. This structure arose from small gravitational instabilities and fills even the apparently empty space between galaxies. The Far Ultraviolet Spectroscopic Explorer satellite, along with the Hubble, has yielded observations that will help test theoretical models of how matter in the expanding universe condensed into this web-like structure. Already, Hubble's new survey camera has produced results exceeding expectations. Hubble continues to take breathtaking images of the intricate structure of the interstellar medium, delineating the influence of star formation, stellar winds, and supernovae on the chemistry and movements of the Milky Way. We also used the Hubble's infrared camera to probe the dust disk structure around the young star TW Hydrae to search for the telltale ripple signature of a planet. So far, we have not found it but we are planning further observations.



NASA provides a detailed look at matter leaving a black hole

Images like this, obtained from the Chandra X-ray Observatory, have given astronomers their most detailed look to date at the X-ray jet blasting out of the nucleus of M87, a giant elliptical galaxy 50 million light years away in the constellation Virgo.

At the extreme left of the image, the bright galactic nucleus harboring a supermassive black hole shines. Strong electromagnetic forces created by matter swirling toward the supermassive black hole may produce the jet. These forces pull gas and magnetic fields away from the black hole along its axis of rotation in a narrow jet. Inside the jet, shock waves produce high-energy electrons that spiral around the magnetic field and radiate. High-speed charged particles such as electrons, emitting radiation while accelerated in a magnetic field, cause this radiation.

Challenges. The foremost challenge in meeting this objective is the sheer diversity of phenomena to observe on all scales—from those as small as the components of a planet's magnetosphere to the largest structures in the universe—and times—from objects almost as old as the universe to stars that have yet to settle into the relatively stable existence of stars like our Sun. Our approach is necessarily diverse. Each observatory brings different insights to the physical processes involved. No one instrument can capture the complete picture.

A multidisciplinary approach is key to progress. For instance, to investigate the formation of planetary systems, astronomers study the late stages of star formation, including the evolution and structure of circumstellar disks, and search directly for planets via the "wobble" signature of the parent star. In addition, imaging of dust disks reveals structures with the telltale signature of orbiting planets.

Plans. High-powered space observatories will advance progress on this strategic objective: The Space Infrared Telescope facility will be launched in FY 2003, and the Stratospheric Observatory for Infrared Astronomy will begin flying in FY 2005. These two complementary infrared observatories will peer through dust and gas to observe the formation of stars and planetary systems. At the end of the decade, the new James Webb Space Telescope will begin observing the first generation of stars and galaxies in the universe. Additional instruments will be added to the Hubble Space Telescope to, again, extend its vision.

Strategic Objective 4. Look for signs of life in other planetary systems

Achievements. The research that supports this goal seeks to (1) discover planetary systems of other stars and their physical characteristics and (2) search for worlds

that could or do harbor life. The following are highlights of FY 2002 accomplishments:

NASA instrumentation on the Keck telescopes in Hawaii continues to discover planets around nearby stars; the total is now more than 100. These discoveries increase understanding of processes that lead to stable planetary systems that could harbor life. A major step in the quest for life outside our solar system is to characterize already-discovered planets.

Hubble has made the first direct detection of the atmosphere of a planet orbiting a star outside our solar system. Spectral analysis of the planet as it passed in front of its parent star allowed astronomers to detect the presence of sodium in the planet's atmosphere. This feat demonstrates the enormous potential of using this technique to study planetary atmospheres and to search for chemical markers of life beyond Earth.

Challenges. This objective's principal challenges are technological. Tantalizing observations—from the ground and from space—have shown that planetary systems are common and that they exist in very diverse forms. However, the next steps in understanding extra-solar planets involve direct detection of their light—a formidable challenge, akin to detecting a firefly next to a searchlight pointing toward you. There are also theoretical challenges in modeling the atmospheres of planets that may be very different from those in our solar system. However, these differences represent not only a challenge but also a tremendous opportunity to learn about exotic planets that do not exist around our Sun, but could have.

Plans. NASA has a phased approach to the technologies and science needed to detect and characterize planets. In the near term, nulling technologies will be demonstrated with the Keck Interferometer and the Large Binocular Telescope in Arizona. Research will continue with the Hubble Space Telescope and NASA-funded ground-based observations to detect and characterize extra-solar planets; this information will set the science requirements for future missions. Later this decade, the Kepler mission will be launched to discover Earth-sized planets. At the end of this decade, the Space Interferometry mission will be launched to survey the solar neighborhood for Earth-like planets. All of these activities will culminate in the Terrestrial Planet Finder, to be launched in the next decade.

Strategic Objective 5. Understand the formation and evolution of the solar system and the Earth within it

Achievements. The research that supports this goal seeks to inventory and characterize the remnants of the original material from which the solar system formed, learn why the planets in our solar system are so different from each other, and learn how the solar system evolved. The following are highlights of FY 2002 accomplishments:

NASA findings allow first chemical analysis of an atmosphere outside the solar system

Astronomers using the orbiting Hubble Space Telescope have made the first direct detection and chemical analysis of the atmosphere of a planet outside our solar system. Shown here as an artist's rendering, the planet orbits a yellow, Sun-like star that lies 150 light-years away in the constellation Pegasus.

Caltech's David Charbonneau and Timothy Brown of the National Center for Atmospheric Research used Hubble's spectrometer to detect the presence of sodium in the planet's atmosphere. This unique observation shows the potential of this method to identify the chemical makeup of alien planets' atmospheres and search for the chemical markers of life beyond Earth. "This opens up an exciting new phase of extra-solar planet exploration," said Charbonneau. "[Now] we can begin to compare and contrast the atmospheres of planets around other stars."

The Kuiper Belt is a collection of icy bodies in a region past the orbit of Neptune. In the past year, NASA-sponsored astronomers discovered Quaoar, the largest Kuiper Belt object to date. At its discovery, the astronomers estimated Quaoar's size to be about 750 miles in diameter. A Hubble image of Quaoar confirmed their estimate. Some astronomers speculate that Kuiper Belt objects as large as the Earth remain undiscovered.

Jupiter's moon Io is the most volcanically active body yet discovered in the solar system. The amount and type of its volcanic activity may shed light on the geological processes that were at work early in the history of the Earth. Our Galileo spacecraft continued its highly productive mission by making two close flybys of Io. The images showed how quickly volcanic eruptions and deposits of volcanic material change Io's surface. During one of these flybys, Galileo detected a volcanic plume approximately 180 miles high, the highest ever seen.

Challenges. Because they reside in the outermost fringes of the solar system, Kuiper Belt objects appear extremely faint. It is difficult to find them, difficult to track them once they have been found, and difficult to determine their physical characteristics. Most of the objects discovered to date are the larger and closer ones, simply because they are the brightest, and therefore, eas-

iest to find. However, we must know the true distribution of sizes of Kuiper Belt objects, their true distribution in space, their compositions, and the nature of cratering on their surfaces in order to understand the processes—including collisions—that were at work during the formation of the solar system.

Plans. In the near future, the results of recent Kuiper Belt discoveries will take studies of the processes and materials that formed the solar system out of the realm of inference and into the realm of conclusions based on hard evidence. From this hard evidence, we may be able to infer more about similar features around other stars.

The search for near-Earth objects (see objective 8 below) has also brought to light some smaller Kuiper Belt objects. Observing such objects with our new Space Infrared Telescope facility will represent a great leap forward in measuring their size. In addition, close-up observations of Pluto and other Kuiper Belt objects from a flyby mission would yield invaluable data about their composition and their cratering and collision histories. A Pluto and Kuiper Belt mission is a top priority of the recent Decadal Survey of Solar System Exploration conducted by the National Research Council.

In September 2003, the Galileo mission will complete its 35th orbit of Jupiter, and the spacecraft will plunge into the planet's atmosphere. Galileo launched in 1989, reached Jupiter in 1995, and since then has returned stunning science data. In July 2004, our Cassini spacecraft will enter orbit around Saturn. Six months later, it will send the European Space Agency's Huygens probe into the dense atmosphere of Saturn's planet-sized moon, Titan. Huygens will sample the physical and chemical conditions of Titan's atmosphere and surface, which may be similar to those on the early Earth. For the next four years, Cassini will study all aspects of Saturn—its satellites, rings, and magnetic field.

Strategic Objective 6. Probe the evolution of life on Earth, and determine if life exists elsewhere in our solar system

Achievements. The research that supports this objective seeks to (1) investigate the origin and early evolution of life on Earth and explore the limits of life in terrestrial environments that might provide analogs for conditions on other worlds, (2) determine the general principles governing the organization of matter into living systems and the conditions for the emergence and maintenance of life, and (3) chart the distribution of life-sustaining environments within our solar system and search for evidence of past and present life. The following are highlights of FY 2002 accomplishments:

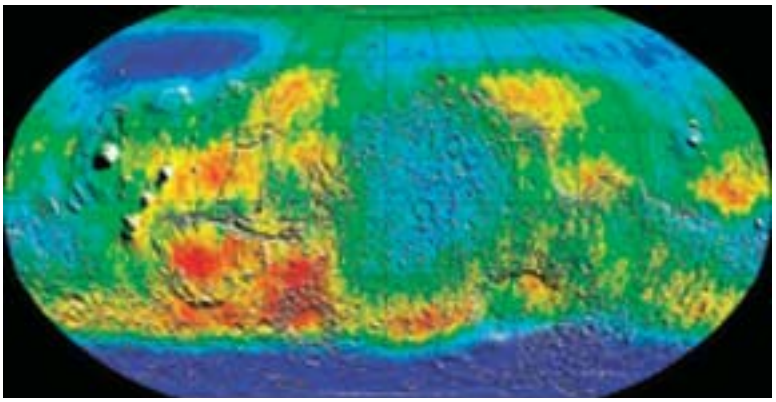
A major achievement in FY 2002 was the Mars Odyssey mission's discovery of extensive high-latitude deposits of water ice beneath a thin veneer of dust on Mars. Ample evidence that liquid water once flowed on the Martian surface has led to the conclusion that the planet was warmer and wetter at some point in its history and therefore may have sustained life. This leads to questions such as: How much water was there? For how long? Where did it go? The Mars Odyssey discovery may provide at least a partial answer to the last question by shedding light on Mars's modern water inventory. Continuing refinement of Mars Global Surveyor observations suggesting that modern outbreaks of liquid water formed gullies has intensified interest in subsurface storage of water in confined aquifers, potentially signaling the presence of subsurface reservoirs worthy of exploration.

We have also learned a great deal about the range of conditions in which life on Earth can thrive. Scientists have recently discovered a large variety of eukaryotic microbes—single cells with nuclei—that thrive in an extremely acidic environment with a high concentration of toxic heavy metals. Scientists have also discovered microbes that can live under pressures about 1,000 times greater than the atmospheric pressure at the Earth's surface. These discoveries increase by tenfold our estimate of the range of conditions under which life might exist in the solar system.

Challenges. The Mars Odyssey experiment that detected subsurface ice on Mars was able to reliably measure to a depth of about 1 meter. There remains the question of whether the ice extends to a greater depth, which would mean there would be much more water than has been discovered so far. Another question is the degree to which the ice in the Martian soil exchanges with the atmosphere and subsurface. This has a direct bearing on the existence of ancient water on Mars.

Plans. In 2004, NASA will deploy twin Mars exploration rovers on the surface of Mars. The rovers will search for geological evidence of the past action of water. If the rovers find mineral or chemical evidence of water-laden sediments on Mars, it will be the first direct evidence that Mars must have harbored persistent liquid water at its surface in the geological past. That information may suggest experiments the 2009 Mars Science Laboratory should undertake to look for organic materials. The laboratory will analyze Mars's surface for organic molecules, isotopic signatures, and other indicators of past biological activity. Before that happens, however, the 2005 Mars Reconnaissance Orbiter will look for evidence of water-laden sediments or active hydrothermal processes to help select the site for the mobile science laboratory. The orbiter will also carry high-resolution subsurface sounding radar to follow up on the Mars Odyssey findings. It may be able to better define the depth to which high-latitude water ice deposits extend. Depending on the landing site selected, the Mars Science Laboratory may be able to conduct in-situ investigations to directly search for subsurface liquid water.

To better understand and measure features related to life both on Earth and beyond, NASA has started two research and technology programs. Astrobiology Science and Technology for Exploring Planets is a new science-driven effort to enable a new generation of planetary exploration through robotic research in extreme environments. As analogs for planets, extreme Earth environments are venues for cutting-edge astrobiology research and for creating advanced exploration capabilities. The program will develop astrobiology instruments, platforms, and operation procedures. We will use these in extreme Earth environments to both validate them and to improve our knowledge of life on Earth. The Astrobiology Science and Technology Instrument Development Program will develop instruments from concept through near-flight ready status.



NASA finds direct evidence of water on Mars

Using instruments on the Mars Odyssey spacecraft, surprised scientists have found enormous quantities of buried treasure lying just under the surface of Mars—enough water ice to fill Lake Michigan twice over.

In this image, the deep blue colors show soil enriched by hydrogen. Light blue, green, yellow, and red colors show progressively smaller amounts of hydrogen. The deep blue areas in the polar regions may contain up to 50 percent water ice in the upper 3 feet of the soil. A layer of carbon dioxide frost (dry ice) hides the hydrogen in the far north. Light blue regions near the equator contain slightly enhanced near-surface hydrogen. This hydrogen is, most likely, chemically or physically bound because water ice is not stable near the equator.

Strategic Objective 7. Understand our changing Sun and its effects throughout the solar system

Achievement. The research that supports this objective seeks to (1) understand the origins of long- and short-term solar variability, (2) understand the effects of solar variability on the solar atmosphere and heliosphere, and (3) understand the space environment of the Earth and other planets. The following are highlights of FY 2002 accomplishments:

For the first time, NASA researchers were able to observe the flow of energy from the Sun's interior to its final deposition in Earth's atmosphere. To do this we are using two new observational satellites—Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics and Reuven Ramaty High Energy Solar Spectroscopic Imager—with older observing systems to provide a new view of Sun-Earth system behavior.

The Reuven Ramaty High Energy Solar Spectroscopic Imager, a NASA explorer mission, provided solar x-ray and gamma-ray images in April 2002 that showed a surprising result. The emission from the hottest flare material appeared just before the lower temperature brightening observed by the Transition Region and Coronal Explorer in ultraviolet light. Theorists now need to figure out an energy release mechanism that would produce the highest temperature plasma first.

At the other end of the Sun-Earth connection that same day, the Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics spacecraft measured the response of the Earth's upper atmosphere. The craft provided the first global surveys of the plasma depletions that can disrupt communications and navigation systems. Those observations combined with those from the Imager for Magnetopause to Aurora Global Exploration spacecraft and other sources show a more direct and immediate link than expected between events in the ionosphere and the magnetosphere.

These missions complement others and provide a new overview of the entire Sun-Earth system that allows improved characterization of cause-and-effect relationships in the flow of energy and matter through the solar system.

Challenges. A magnetic variable star modulates our solar system and our home planet—a fact that increases in importance as our increasing use of technology makes us ever more vulnerable to solar disruptions. As we learn more about the elements of the Sun-Earth system, their interconnected nature gains importance. We must make the best use of existing assets and incorporate new findings to provide urgently needed knowledge about the Sun-Earth system.

Sun-Earth connection science is challenging because conditions vary rapidly and on fine spatial scales near Earth, at the Sun, and in the solar wind. Measurements are extremely sparse even in the areas of greatest physical interest, so distinguishing position information from temporal changes requires observations from multiple sensors and multiple spacecraft. Further, combining and understanding these data demand advanced database and data analysis tools.

Continued progress requires development of advanced mission concepts to expand our knowledge of the system's physical characteristics and the processes for transmission of energy and matter through it. To achieve the National Space Weather Research Program's goals, we will need to

develop better detection hardware and analytic techniques. Providing the most useful data demands balanced use of assets based on a careful review process.

Plans. The Sun-Earth connection spacecraft will continue to study specific topics such as helioseismology—the study of the interior of the Sun. However, we will place more emphasis on using the spacecraft to study the behavior of the Sun-Earth system.

We will continue to formulate and develop missions for the Solar Terrestrial Probes and Living With a Star Programs. We will continue to pursue new partnerships, such as the International Living With a Star Program, and make cost-conscious development choices to augment both programs. Partnerships are an excellent way to maximize return for NASA and other organizations. Potential Sun-Earth connection partners include the U.S. Air Force, the European Space Agency, the National Oceanic and Atmospheric Administration, the National Science Foundation, and U.S. industries.

We are planning a new operational program to investigate the heliosphere using existing Agency assets. One possibility is a plasma turbulence investigation to learn how to anticipate space weather effects on the Earth's magnetosphere and ionosphere more accurately.

Strategic Objective 8. Chart our destiny in the solar system

Achievements. The research that supports this objective seeks to (1) understand the forces and processes, such as asteroid impacts, that affect the habitability of Earth; (2) develop the capability to predict space weather; and (3) find extraterrestrial resources and assess the suitability of solar system locales for the future of human exploration. The following are highlights of this year's accomplishments:

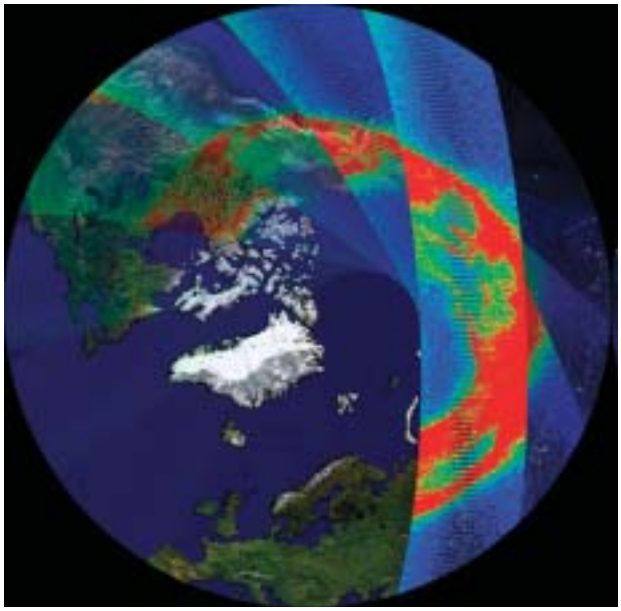
The effects of asteroid impacts on Earth became evident in the early 1980s when scientists first associated the extinction of the dinosaurs with an asteroid impact. More recently, numerical modeling suggests that impacts by asteroids as small as 1 kilometer in diameter could cause global climate changes, some of which would be globally devastating. At the direction of Congress, NASA supports a program to discover 90 percent of the near-Earth objects larger than 1 kilometer by 2008 and to determine their orbits with sufficient accuracy to predict whether any of them pose a threat to Earth. In the past year, scientists have cataloged 104 new near-Earth objects larger than 1 kilometer; the total number discovered to date is 628. Fortunately, none of these poses a foreseeable threat to Earth.

Space weather affects many technological systems. During large solar particle events, energetic particles enter the Earth's magnetosphere above a highly variable, but predictable cut-off latitude. Measurements by NASA's Solar Anomalous and Magnetospheric Particle Explorer show that the actual geomagnetic cutoffs generally fall below previously calculated values and that the Earth's polar cap is larger than we had expected. At these times, the radiation dose at satellites such as the Station is several times greater than expected, with effects for both humans and equipment on board.

Challenges. The near-Earth object survey involves a highly specialized form of astronomy that requires searching for extremely faint objects over large portions of the sky. Fortunately, large-format electronic imaging detectors that have become available in recent years, combined with powerful computer software that automates the search for faint objects in the images, have dramatically increased the productivity of these search efforts.

Improving space weather forecasting requires understanding of the interactions of complex systems. This new science requires cross-disciplinary coordination of research at every level, from instrument development, to data collection, to analysis and interpretation.

Plans. NASA has commissioned a science definition team to study the feasibility and cost of extending the



NASA records Earth's response to strong solar storms

NASA's Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics spacecraft observed the response of Earth's upper atmosphere to a series of strong solar storms that occurred in late April 2002, providing important new information on the final link in the Sun-Earth Connection chain geared toward explaining the physical processes connecting the Sun and Earth.

Data from the Global Ultraviolet Imager instrument shows intense auroras, indicated in red, occurring over the northern polar region during solar storms and extending much further south than usual. Several data tracks, acquired during multiple spacecraft passes, are superimposed over an Earth image to show the location of the auroras. One of the questions Sun-Earth Connection scientists are trying to solve is how and why Earth's atmosphere responds differently to various types of solar storms.

near-Earth object search to include much smaller objects that are capable of causing regional devastation. However, these objects are much more numerous and much fainter than the objects larger than 1 kilometer on which we are currently focusing. The science definition team will estimate the assets needed to detect these small objects; the volume of data that would need to be collected, transmitted, and stored; and the magnitude of the computational effort.

NASA's new camera captures unprecedented detail

The Advanced Camera for Surveys, the newest camera on NASA's Hubble Space Telescope, has captured a spectacular pair of galaxies engaged in a celestial dance of cat and mouse or, in this case, mouse and mouse, located 300 million light-years away. The image of the merging galaxies shows more detail and more stars than ever before.

In the galaxy at left, the bright blue patch is a vigorous cascade of clusters and associations of young, hot blue stars, whose formation was triggered by the tidal forces of the gravitational interaction between the two galaxies. Streams of material can also be seen flowing between the two galaxies. The clumps of young stars in the long, straight tidal tail (upper right) are separated by fainter regions of material. These dim regions suggest that the clumps of stars formed from the gravitational collapse of gas and dust that once occupied those areas. Some of the clumps have luminous masses comparable to dwarf galaxies in the halo of our own Milky Way Galaxy.

The Living With a Star Program will continue developing focused missions, conducting its engineering test bed flight program, and further defining the data environment. Partnerships within the International Living With a Star Program will augment what our program can achieve independently.

Strategic Objective 9. Support of Strategic Plan science objectives; development/near-term future investments (Supports all objectives under the Science goal)

Achievement. The American people have chartered NASA to explore our solar system and the universe beyond, building and launching missions to achieve ambitious scientific goals. Several highly innovative missions are now in design and fabrication. Once launched and operational, we expect them to provide images and data that will significantly advance our understanding of our solar system and universe and educate and inspire the next generation of explorers.

Highlights for FY 2002 included the successful launch and start of operations of several missions, including:

- Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics, launched in December 2001 to study the highest levels of Earth's atmosphere and how it interacts with wind from the Sun
- The Reuven Ramaty High Energy Solar Spectroscopic Imager, launched in February 2002 to study solar flares
- The fourth Hubble Space Telescope servicing mission, completed in March 2002, which multiplied Hubble's power by about a factor of 10.

In addition, NASA is building and testing more than a dozen other space science missions that we will launch in FY 2003 and 2004. Data from this generation of spacecraft will reshape humanity's understanding of the universe and our place in it.

Challenges. Building robotic spacecraft to tease out the secrets of the universe will always be challenging. Each spacecraft is unique and complex, with greater capabilities than its predecessors had, and presents its own set of technical hurdles to be overcome before launch. In designing, building, and testing these spacecraft, we must balance the competing goals of scientific capability, reliability, and cost. We must accept some risk, while learning from our mistakes and doing everything reasonable to ensure mission success. Managing diverse and complex missions is not a trivial challenge, but our record is overwhelmingly one of success.

Plans. After the well-publicized failures of the Mars Polar Lander and Mars Climate Orbiter missions in late 1999, we intensively reviewed our mission design and development processes. We made numerous changes, including increasing prelaunch testing requirements and making use of independent review teams. Despite these changes, we will continue to face the challenges noted above because we must balance the competing goals of scientific capability, reliability, and cost. Nevertheless, the long-term trend over the last several decades is one of increasing success, and we will strive to continue the trend.

Strategic Goal 2. Technology/Long-Term Future Investments: develop new technologies to enable innovative and less expensive research and flight missions.

New high-technology equipment and materials must be ready for use in future space science missions, many of which are impossible without them. Technology activities can range from basic research to flight-ready development.

Our research and technology development approach requires that we overcome all major technological hurdles before a science mission's development phase begins. In FY 2002, we achieved 100 percent of our performance measures for this strategic goal.

Strategic Objective 1. Acquire new technical approaches and capabilities. Validate new technologies in space. Apply and transfer technology

Achievements. *Science theme: Sun-Earth connection*—The New Millennium Program flight-validates emerging technologies. We restructured the program to increase openness and competition, reduce mission size and cost, and ensure that we focus on demonstrating technology rather than gathering science data. In FY 2002, the Space Technology-5 mission proceeded to manufacturing, testing, and integration. This mission will flight-demonstrate a miniaturized spacecraft that performs just like larger satellites, but benefits from the cost advantages of smaller size. Its instruments will deliver high-altitude space weather data.

Scientific theme: Astronomical search for origins—During 2002, the James Webb Space Telescope (formerly the Next Generation Space Telescope) team selected TRW, Inc., (now part of Northrop Grumman Corporation) as prime contractor.

Science theme: Solar system exploration—The In-Space Propulsion Program develops new mission technologies to reduce trip times, increase payload capabilities, and reduce propulsion system costs. This year the program selected several propulsion technology proposals for further development:

- Aerocapture uses a planet's atmosphere, rather than on-board propulsion, to slow a spacecraft enough to enter orbit around a planet. Carrying less fuel for a braking maneuver makes it possible to conduct long-term orbital missions, instead of planetary flybys.
- Nuclear electric propulsion may eventually greatly improve the capability, sophistication, and reach of science missions.
- Solar sails—thin, lightweight membranes propelled through space by sunlight—may offer a relatively inexpensive, propellant-free way to travel through the solar system.

These awards were openly competed and awarded to researchers from industry, universities, and NASA Centers.

Scientific theme: Structure and evolution of the universe—The Gamma-ray Large Area Space Telescope will observe thousands of black holes, magnetized pulsars, and gamma-ray bursts throughout the universe, directly contributing to NASA's mission to explore the universe. In 2002, the team completed the telescope's preliminary design phase and began instrument development.

Challenges. In 2002, the New Millennium Program encountered problems because of a lack of available launch vehicles. As a result, the Space Technology-5 mission, previously scheduled for launch in May 2004, will be delayed at least 6 months.

The propulsion technologies recently selected for development involve many groups that must coordinate and communicate well. An organizational change may be necessary to ensure this.

Plans. Because of the difficulties encountered with launch availability, NASA is pursuing alternative procurement strategies to obtain the required launch vehicle for the Space Technology-5 mission and to resolve the issue for future missions.

The Living With a Star Program will move forward with the Solar Dynamics Observatory and other missions that will observe the Sun and track disturbances originating there. The program will place constellations of small satellites around the Earth to measure effects here.

The In-Space Propulsion Program is continuing to explore several exciting technologies for future exploration of our solar system. For example, our future robotic spacecraft may cruise among the planets like sailboats in space or perhaps be propelled from planet to planet by advanced ion engines.

Strategic Goal 3. Education and public outreach: share the excitement and knowledge generated by scientific discovery and improve science education.

NASA met its space science education and public outreach performance goals for FY 2002 by satisfying seven out of the eight performance objectives for this strategic goal. This performance continues a trend of rapid growth in space science education and public outreach activities. This growth is the outcome of the policy that every NASA space science research program and flight mission must include a substantial education and public outreach effort.

Strategic Objective 1. Share the excitement of space science discoveries with the public. Enhance the quality of science, mathematics, and technology education, particularly at the pre-college level. Help create our 21st century scientific and technical workforce

The extent and breadth of our space science education and public outreach activities in FY 2002 was substantial. We carried out about 330 activities and produced 70 new products during the year. Because many of these activities were multiple events, the total number of events was 3,700. The events took place in all 50 states, the District of Columbia, and Puerto Rico. Some 350,000 students, teachers, and members of the public participated directly in NASA space science education and public

outreach activities in FY 2002. An additional 6 million people participated in Web activities. The following are highlights of FY 2002 achievements:

External evaluations of space science education and public outreach activities indicated that their effect on audiences was very positive. Educators found the number and diversity of NASA space science educational materials impressive, appreciated the hands-on nature of the materials, and reported that their students found the materials exciting and engaging. We received awards for our education and public outreach efforts from the National Science Teachers Association, the National Academy Press, and the American Library Association, among others.

NASA helps students explore Mars

A group of small, unnamed craters in the Martian southern hemisphere was the first site captured by a group of middle school students who operated the camera system onboard NASA's Mars Odyssey spacecraft. The acquisition of the image marked the beginning of the Mars Student Imaging Project, a science education program funded by NASA and its Jet Propulsion Laboratory and operated by the Mars Education Program at Arizona State University. The project gives thousands of 5th to 12th grade students the opportunity to do real-life planetary exploration and to study planetary geology using Odyssey's visible-light camera.

"It was incredible to watch their faces. They really understood and appreciated what they were doing and that they were the first people on Earth to see that place on Mars," said Dr. Philip Christensen, the camera system's principal investigator at Arizona State University. Here, students study Mars images and image processing.

Our education and public outreach partnerships with more than 500 major scientific, Government, and educational institutions or organizations enhanced the effort. In FY 2002, these partners included major curriculum developers such as the Mid-continent Research for Education and Learning and the Lawrence Hall of Science; educational and scientific professional societies such as the National Science Teachers Association, the Association of Science-Technology Centers, Inc., and the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers; Government agencies and organizations such as the Smithsonian Institution, the Lawrence Livermore National Laboratory, and the National Science Foundation; community organizations such as the Girl Scouts of the United States of America, the Boys & Girls Clubs of America, and the Civil Air Patrol; more than 150 museums, science centers, and planetariums; and more than 75 colleges and universities, including nearly 30 minority institutions.

The 15 minority institutions first funded in FY 2001 under the NASA Minority University Education and Research Partnership Initiative in Space Science to develop space science capabilities on their campuses continued to make tremendous progress. In academic programs, the 15 minority institutions reported that they have established on their campuses 22 new or redirected space science faculty positions, 11 new or revised space science degree programs, and 66 new or revised space science courses. Notable among these programs was a new system-wide space science degree program established at the City University of New York that is open to students at any college within its system.

Challenges. Feedback about the quality of the space science education and public outreach program and its educational effect on the audiences it serves came during FY 2002 from three major sources: (1) discussions at the Chicago NASA Space Science Education and Public Outreach Conference, (2) a task force chartered by the NASA Space Science Advisory Committee, and (3) the Program Evaluation and Research Group of Lesley University. This is the first time that such feedback on program outcomes and effects has been available. Finding ways to respond to it is the major challenge facing the NASA space science education and public outreach program in FY 2003.

The feedback led to the following conclusions:

The program should improve the coherence of its education products, review them critically for quality, and base them more closely on curriculum standards. The program needs to provide training in education for its education and public outreach specialists, who are often scientists or technologists who have adopted education as a new career. The NASA Space Science Education Resource Directory needs to be more accessible to educators from two standpoints: We should advertise it better; and we should make it easier and faster to use with better search options.

Plans. Responding to the feedback received in FY 2002 is the major program priority for FY 2003. We will give serious attention to improving the coherence of the vast array of space science educational resources that we produce and offer. A working group of the NASA Space Education

Council will examine the idea of establishing a space science curriculum as the foundation for this coherence. We will also explore options for providing professional development opportunities for the providers of NASA space science education and public outreach. We are already developing procedures for evaluating the quality of educational materials in the Space Science Education Resource Directory, making the results of those evaluations available to users, and including audio-visual and print materials in the directory. We will fully implement these procedures and will devote attention to publicizing the directory to a wider audience, making it easier to locate and use, and adding additional search capabilities. These processes will be integrated wherever possible with the development of a new NASA-wide education Web portal.

We will continue to explore options for acquiring the staff time necessary to review the education and public outreach programs of missions during their development and implementation phases. We will fold these needs into the staffing plans being developed by the new NASA education organization.

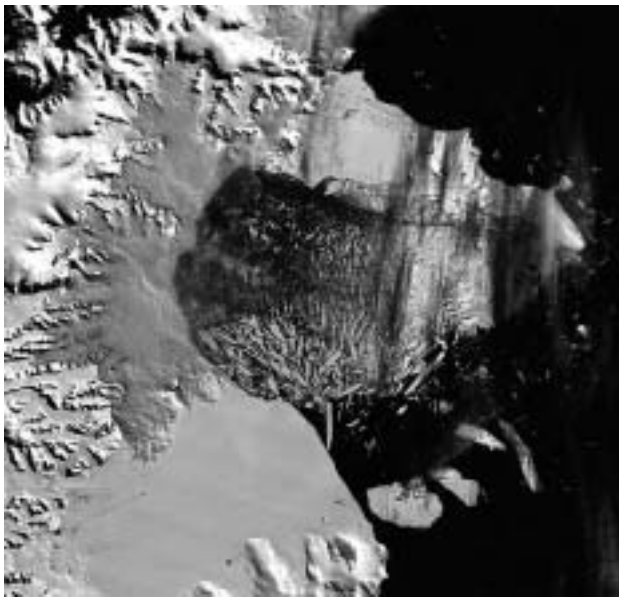
We will make several improvements in the annual performance goals for FY 2003. The metric that every mission have a funded education and public outreach program will be revised and clarified to distinguish requirements for stand-alone missions from those for umbrella programs that involve several missions. We will establish performance measures for measuring the involvement of space scientists in education and public outreach. We will delete the measure calling for a space science education and public outreach annual report because production of this report is routine. We will add a metric for developing distribution mechanisms for non-electronic materials.

Earth Science

MISSION: Develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved predection of climate, weather, and natural hazards for present and future generations

NASA seeks to understand the total Earth system and the effects of nature and people on the global environment. This effort is integral to our mission to better understand and protect our home planet. From space, NASA provides information about Earth's land, atmosphere, ice, oceans, and life that is obtainable in no other way, providing a view of our environment as only NASA can. NASA uses satellite systems to study the interactions among these Earth components to advance Earth-system science. Our research results form the basis of environmental policy and economic investment decisions that serve our society and better life.

NASA develops innovative technologies and science-based applications of remote sensing to solve practical societal problems in agriculture and food production, natural hazard mitigation, water resources management, regional planning, and national resource management. We collaborate with other Federal agencies, industry, and State and local governments. We enhance the science, mathematics, and technology education of all Americans. NASA combines the excitement of scientific discovery with the reward of practical contributions to the success of our planet while inspiring the next generation of explorers.



NASA tracks ice shelf disintegration

Moderate-Resolution Imaging Spectroradiometer satellite imagery analyzed at the University of Colorado's National Snow and Ice Data Center revealed that the northern section of the Larsen B ice shelf, a large floating ice mass on the eastern side of the Antarctic Peninsula, has shattered and separated from the continent. The shattered ice formed a plume of thousands of icebergs adrift in the Weddell Sea. The shelf is now 40 percent the size of its previous minimum stable extent. For reference, the area lost in this most recent event dwarfs Rhode Island in size.

This is the largest single event in a series of retreats by ice shelves in the peninsula over the last 30 years. The retreats are attributed to a strong climate warming in the region.

Strategic Goal 1. Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth

Using space for cutting-edge research about Earth has become a NASA hallmark. In FY 2002, numerous satellite missions, field campaigns, and data analyses improved our understanding of Earth. We increased our understanding of Earth's global carbon cycle, global water cycle, long-term climate variability, atmospheric composition, and the planet's interior and crust. We achieved 20 of 22 performance goals for a 91-percent success rate, and we intend to achieve all our performance goals in FY 2003.

Strategic Objective 1. Discern and describe how the Earth is changing

Modern observational techniques have revolutionized our abilities to explain global phenomena associated with nature- and human-induced environmental change. Part of our success stems from the accurate data sets we collect, which, in turn, permit us to address changes in Earth systems in a quantitative way. NASA's state-of-the-art, space-based observational methods extend both our view of previously observed global environmental parameters and our measurements over a progressively longer period. Thus, we can make global environmental observations that were previously not possible. Advances in FY 2002 included discoveries about sea ice, ocean biology, and polar ice sheets.

Scientists are intrigued with the discrepancy in Arctic and Antarctic ice changes. While Arctic ice decreased by several percent per decade between 1979 and 2000, Antarctic ice increased slightly. Scientists are also studying how the Arctic ice's retreat could significantly affect ocean circulation. In the ocean biology field, combined data sets from two different satellite instruments contribute to our knowledge of phytoplankton distribution in the oceans. This microscopic organism plays a big part in ocean life and is the foundation for the marine food chain. Phytoplankton play an important role in the exchange of carbon between the biosphere and atmosphere. The exchange contributes to the buildup of atmospheric carbon dioxide that can, in turn, affect climate. From space, NASA's Terra and Aqua satellites help scientists investigate the differences on a

global scale between living and nonliving organisms in coastal regions and estimate the capacity for photosynthesis in coastal and oceanic areas.

In our study of polar ice sheets, we have also used information about ice-covered regions in polar areas, such as Greenland and Antarctica, to make quantitative assessments of changes in ice cover, especially at the margins between ice sheets and the ocean. This knowledge helps scientists test climate models and improves our ability to assess potentially hazardous changes in sea level and sea ice distributions.

Challenges. Providing global data sets presents two major challenges when studying Earth-system variability. First, scientists have to synchronize data from multiple satellite instruments without introducing errors. This challenge can be exacerbated because scientific instruments degrade in the harsh space environment. Calibrating such instruments as they change over time is difficult enough, but combining data from two or more instruments that need adjustments increases the uncertainty. Second, scientists have to validate space-based remote sensing measurements acquired over environmentally harsh areas of the globe, such as at high latitudes or in tropical forests. Thus, NASA needs vigorous calibration and validation programs that use airborne simulators of satellite instruments, moorings (underwater instrumentation), and high-performance aircraft that can fly over regions of interest coordinated with satellite measurements.

Plans. NASA will focus on assuring the calibration and validation of data from the Aqua satellite and the integration of data between instruments on both the Terra and Aqua satellites in FY 2003. We will focus on integrating ocean topography data from the Jason satellite and its predecessor the Topex/Poseidon satellite, as well as atmospheric aerosol and ozone data from the Stratospheric Aerosol and Gas Experiment instruments launched in 2001 and 1984. Validation of the Ice, Clouds, and Land Elevation Satellite (IceSat) measurements of ice sheet elevations will be a major priority.

The FY 2003 plan structure remains the same as that of FY 2002's plan. Starting in FY 2004, NASA will develop detailed roadmaps that define program elements addressing relevant science questions and the timing of their achievability. These multiyear roadmaps will form the basis for future annual performance plans and provide further insight into longer-term Earth-system research.

Strategic Objective 2. Identify and measure the primary causes of change in the Earth system

Achievements. NASA looks at primary drivers of global change, including distributions of radiatively and chemically active trace gases and aerosol particles, solar irradiance, and land cover and land use change. Some particular highlights of FY 2002 included the following:

Data from several NASA spacecraft, including Terra, the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) satellite, and the Total Ozone Mapping Spectrometer (TOMS) instrument helped establish an unprecedented database with information on not just aerosol presence but also the nature of the aerosol particle. For example, we were able to observe whether the particle absorbs enough solar radiation to have a net warming or cooling effect on a local climate, its height, and its interaction with the underlying climate. In combination with ground-based data, this information can help scientists understand the influence of atmospheric aerosols on local weather, agricultural productivity, and air quality.

The Landsat satellites and their terrestrial images helped scientists study how land use and changes in land cover affect regional and local economies. Specifically, satellite information used to make observations of crop productivity, the availability of fresh water, and urban growth throughout the country. In the past year, studies focusing on the Mojave Desert, southwestern rangelands, and metropolitan and nonmetropolitan Michigan were published. These data also feed into studies of how land use change can influence the distribution of carbon between the atmosphere and biosphere, and thus provide a basis for future approaches to dealing with carbon emissions and uptake.

Challenges. A major challenge in studying atmospheric aerosols is data integration. For example, the global aerosol observations use several experimental techniques, including visible/infrared and ultraviolet space-based observations and multiangle observations from a satellite with nine cameras pointing in different directions. Ground-based instruments also provided information. Representing what aerosols do in a global climate model means accounting for these very diverse types of measurements. In addition, given the complexity of atmospheric aerosols, which can differ by source (for example, fossil fuel combustion, biomass burning, and mineral desert dust), and by day, is a major undertaking. Through NASA's Global Aerosol Climatology Project NASA has taken the first step toward integrating surface, in situ, and satellite observations to provide a validated climatology of the atmospheric aerosol content over oceans.

A second challenge is integrating data across multiple spatial scales. The observations of land cover are made at high spatial resolution, but spatial coverage of a specific region is limited to relatively infrequent observations. For example, Landsat satellites cover an area in 16-day intervals. More frequent observations come from lower resolution data, most notably the Moderate Resolution Spectroradiometer instruments that fly aboard the Terra and Aqua satellites. These instruments cover different times of the day (Terra in the morning, Aqua in the afternoon). Optimizing the different sources represents a chal-

lenge but provides a unique opportunity to combine the benefits of different instruments.

Plans. NASA's FY 2003 Earth-system activities will focus on integrating data sets from multiple platforms. In particular, we will focus on making Terra and Aqua spacecraft data correspond under different cloud conditions in the later morning versus the early afternoon. We will give attention to ensuring that aerosol observations are rigorously tied to in situ information. Results from in situ measurements of clouds and aerosol particles during the Cirrus Regional Study of Tropical Anvils and Cirrus Layers—Florida Area Cirrus Experiment off the coast of Florida in the summer of 2002 will be used to refine the algorithms from remote sensing. These data may help researchers improve our understanding of how particulate matter affects our global environment.

Strategic Objective 3. Determine how the Earth system responds to natural and human-induced changes

Achievements. Understanding how the Earth system responds to natural and human-induced change is paramount in our efforts to model potential future climate change accurately. One reason the Earth system is so complex is the existence of many feedback processes in which the response of the Earth to forcing can, in turn, represent a forcing to the Earth system. NASA provides the tools needed to characterize and generalize the processes that will play a large role in determining our planet's future. Particular areas of substantial advances in FY 2002 include clouds, ocean dynamics, and stratosphere/troposphere coupling.

A major uncertainty in climate change models is cloud representation because of clouds' enormous variety in terms of time, space, and physical properties, such as size, shape, and the density of particles. Improving our understanding of clouds requires satellite observation and in situ measurements by aircraft of particle distributions and properties. Linking the two observation methods helped NASA understand cloud effects on atmospheric radiation in FY 2002. In particular, data from Terra spacecraft helped map the global cloud distribution and the effect on atmospheric radiation, especially for previously difficult to observe thin cirrus clouds. The results should allow improvements in the characterization of cloud formation in climate models.

A second area of accomplishment is in ocean circulation and dynamics. The Earth's oceans have been one of the most under sampled regions of the global environment because of the difficulty of making repeated measurements in the open ocean. Satellites, however, provide a way to obtain that repeatability. In FY 2002, the results of several years of observations were put into models. Scientists modeled more than a decade of observations of sea surface height measured with the Topex/Poseidon satellite. Additionally, the SeaWinds instrument aboard NASA's Quick Scatterometer (QuikScat) satellite, which gave 3 years of observations of the wind field at the ocean surface that drives ocean circulation, provided the basis for another assimilation model. Both help us understand how ocean circulation affects climate, including the processes by which the Pacific Ocean transitions from an El Niño to a La Niña state.

Our third accomplishment was in the area of stratosphere-troposphere coupling. The exchange of material and energy between the Earth's troposphere and stratosphere has an important influence on the Earth's climate. In particular, increases in the amount of water vapor observed in the stratosphere over the past two decades represent a significant radiative forcing on the climate system. In FY 2002, NASA's satellite and theoretical studies improved our knowledge of how water is transported from the troposphere into the stratosphere and the role that high-altitude cirrus clouds play in this process.

Challenges. Earth-system science researchers are challenged to define global parameters for measurements of climate phenomena and then to create accurate computer simulations that incorporate those data. Only through well-conceived and carefully executed joint satellite and in situ observational campaigns can the best of both methods be combined to reflect the behavior of the Earth system and represent it in global models.

Plans. We intend to link satellite capabilities with field campaigns using aircraft and ground-based instruments. Anoter major activity will involve coincident airborne observations with the Stratospheric Aerosol and Gas Experiment instrument to study the interplay between ozone, aerosols, and water vapor in the Arctic region during winter.

Strategic Objective 4. Identify the consquences of change in the Earth system for human civilization

Achievements. While Earth science is a global science and global-scale changes are of great scientific interest, individuals, governments, and industry see changes at the local and regional levels. Similarly, while changes in the mean state of the Earth are important, extreme events such as droughts, floods, and fires may have greater influence because of the role that they play in the sustainability of ecosystems, communities, and the economy. NASA advances include work in precipitation and coastal studies.

Until recently, we knew surprisingly little about the extent of precipitation over much of the Earth's surface, especially in tropical regions over major oceans. These areas have a major effect on several elements of the Earth system, including atmospheric circulation and oceanic conditions. Data from several years of operation of the

Tropical Rainfall Measuring Mission satellite reduced by a factor of 2 the uncertainty in the global rainfall distribution in the Tropics, and our knowledge of the variation in precipitation from year to year was dramatically enhanced. Further, we used the precipitation data and the QuikScat ocean surface wind data to improve short-term prediction models that account for the track, intensity, and precipitation of tropical cyclones. This knowledge will be useful in overcoming the challenge of properly representing precipitation in global climate models, a significant obstacle in the past decade.

The coastal regions of the world are becoming ever more populated, and thus more vulnerable to negative environmental influences, such as flooding and beach erosion from storm surges. Coastal regions are also subject to a range of other environmental changes. For example, the coasts are affected by pollution, land-use change, and changes in ocean surface temperatures, currents, and height. NASA satellites document natural and human-induced changes along coastal regions and in coral reefs. Data from Landsat, SeaWiFS, and NASA's Earth Observer–1 (EO–1) technology satellite are all being used to map coral reef areas. Data are also used to provide information on suspended sediments in turbid coastal waters. The observations help us study local water pollution.

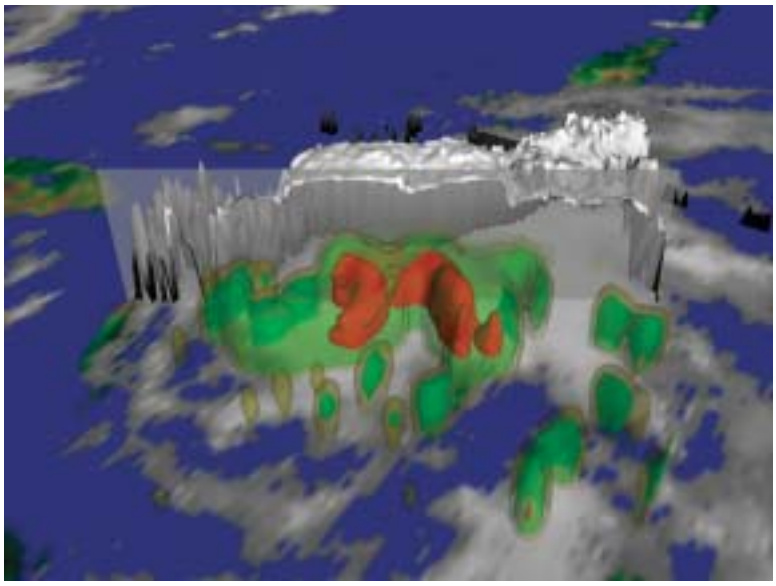
Challenges. Satellite data require scientists to harness the full power of satellites at the spatial resolution needed to represent local and regional behavior. This includes linking global models to those of a smaller scale and finding ways to interweave very high-resolution satellite and airborne observations with lower resolution data. Scientists also must find ways to use new types of observational capabilities, for instance the hyperspectral information available from NASA's EO–1 satellite.

Plans. Our plans center on linking satellite observations with local and regional models. In particular regions, we can address the issue of interest by using the full wealth of available data. By linking observational information at different spatial scales, we can combine the benefits of high resolution with those of frequent coverage and thus produce environmental information that is of greatest use to regional and local policy and decision makers.

Strategic Objective 5. Enable the prediction of future changes in the Earth system

Achievements. NASA melds our knowledge of Earth-system variability, natural and human-induced forcings, and Earth-system processes to produce modeling tools and computational systems for environmental prediction. Our contributions to the Nation's efforts include new kinds of environmental data, modeling approaches, and data assimilation systems that improve modeling capability. As a new capability is developed, it is NASA's goal to transition this capability to operational agencies within Government, such as the National Oceanic and Atmospheric Administration. Particular areas of accomplishment for NASA in FY 2002 in the area of environmental prediction include weather forecasting, seasonal climate prediction, and long-term climate prediction.

Data from NASA's Tropical Rainfall Measuring Mission and QuickScat satellites are regularly used in weather prediction by domestic and foreign agencies. Both satellites improve predictions about hurricanes and other tropical cyclonic systems as they move from the open ocean to coastal regions. Reducing hurricane-tracking error involves pinpointing smaller regions for evacuation in advance of a predicted landfall. Better forecasts have significant societal effects, including cost reductions.



NASA provides three-dimensional hurricane analysis

Hurricane Isidore first developed from a tropical disturbance north of Venezuela on September 14. Isidore brought 80 mph winds and tremendous rainfall to Cuba and was being watched for possible landfall along the U.S. Gulf Coast. By peeling away the clouds, this image reveals inches of rain falling per hour. Yellow represents areas of at least 0.5 inch, green shows at least 1 inch, and red depicts more than 2 inches. This type of analysis improves forecasts of intensity and storm tracking and assists in recovery efforts following a storm.

Improving seasonal forecasting can help people and governments make better decisions about a range of environmental issues, especially those related to agriculture, energy, and water resources. NASA's data and modeling efforts are making significant advances. Observations of ocean surface topography are used as experimental input in seasonal weather and short-term climate models, and these models help to show what is happening in the oceans. Fully linked atmosphere, ocean, and land models provide regular input to national and international modeling efforts aimed to improve short-term climate prediction. They form the basis for studies of regional effects of transient climate variation, most notably changes associated with floods and droughts in North America and the Asian/Australian monsoon regions.

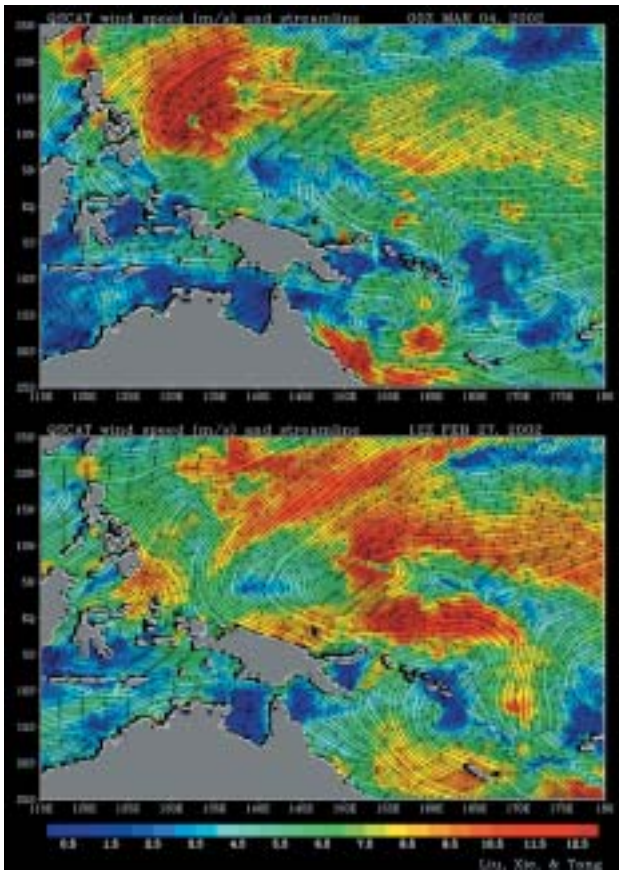
Finally, long-term climate prediction requires, at a minimum, models that include forcing factors for climate change and an understanding of their relative importance. Forcing factors can be any natural or human-induced force acting on the Earth system. NASA created a hierarchy of global climate models using satellite data on climate forcing factors such as solar irradiance, aerosol distributions, land cover and use, and distributions of radiatively active trace gases. The models help address the environmental effect associated with alternative scenarios for reducing greenhouse forcing through potential short-term reductions in emissions of tropospheric methane and black carbon. They also showed that emissions of black carbon may have a regional effect on precipitation distribution and a more global radiative effect. The NASA studies have had a major effect on the climate policy debate in this country.

Challenges. A major challenge is creating multiple climate models that integrate massive amounts of data in a timely fashion to meet our customers' needs. The combined demands for large amounts of satellite data and very demanding models puts an enormous strain on our available computer resources, and requires scientists to think very creatively about optimizing the output. Although we have made progress with the rate of data assimilation and modeling using massively parallel computational systems, more must be done to address the software environment of models, the model designs, and the science. A modeling framework that puts the best components and investigators' ideas into one suite of climate models is needed.

Plans. NASA's plans for Earth-system prediction are described in the challenges section. They also include the more rapid inclusion of newly available global satellite data in our modeling systems. NASA will focus on two cooperative centers, established with the National Oceanic and Atmospheric Administration, to assist in transferring models into operational weather and climate forecasting, with a special emphasis on assuring that the Aqua satellite's full capabilities will be used for weather and climate models. We will use Terra's aerosol information in climate models and airborne process data to construct models of cloud processes and atmospheric ozone chemical processes. The improved models will aid economic and policy decision makers.

Strategic Goal 2. Expand and accelerate the realization of economic and societal benefits from Earth science information and technology

By working in partnership with other Federal agencies, NASA continues to address natural threats of highest concern to our Nation through joint efforts in the areas of wildfire protection, with the U.S. Forest Service, and hurricane



NASA identifies early indicators of climate change

QuikScat, a NASA satellite instrument that measures winds, observed a strong typhoon (top) threatening the Philippines, as well as a similar tropical cyclone passing along the Australian coast toward Nuomea on March 4, 2002. These unusual phenomena are results of the westerly winds (blowing from Indonesia toward the American coast) along the equator that started on February 25 (lower). Color in these QuikScat images relates to wind speed; the arrows indicate direction.

The reversal of the usual Trade Winds (which normally blow from the American coast toward Asia) generally triggers Kelvin waves (warm surface water that moves along the equator from Indonesia to the coast of Peru) and twin cyclones: a counter-clockwise vortex in the Northern Hemisphere and a clockwise vortex in the Southern Hemisphere. The reversed Trade Winds push warm water from west to east across the Pacific, reaching the American coast in one to two months. The increase in frequency and strength of the Kelvin waves may lead to El Niño.

prediction with the National Oceanic and Atmospheric Administration. In this strategic goal, we achieved two annual performance goals for a 100-percent success rate.

Strategic Objective 1. Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private-sector decision makers

Achievements. To accelerate and expand the application of NASA's Earth science results, we created the Applications Strategy: 2002-2012, which is available at http://www.earth.nasa.gov/visions.

The program initiated activities with partner Federal agencies and national organizations in each of 12 national applications areas. For example, NASA is helping the U.S. Forest Service with fire management by providing real-time access to satellite data. We are working with the FAA and the Radio Technical Commission for Aeronautics to establish guidelines for the use of remote sensing data in terrain databases that will serve aviation worldwide. We are working with the Centers for Disease Control and Prevention and the National Center for Environmental Health in a first-of-its-kind public-health decision-support system designed to systematically collect and analyze human environmental exposure information supported by measurements from Earth-observing systems. In collaboration with the National Imagery and Mapping Agency, NASA completed 30-meter-resolution digital elevation models of the Western Hemisphere as part of the Shuttle Radar Topography Mission. These data will be used in watershed management, flood remediation, and ecosystem management.

The activities link NASA's space-based and airborne observational missions and science predictions to the partner agency's decision-support system needs and improve management and policy decision-making.

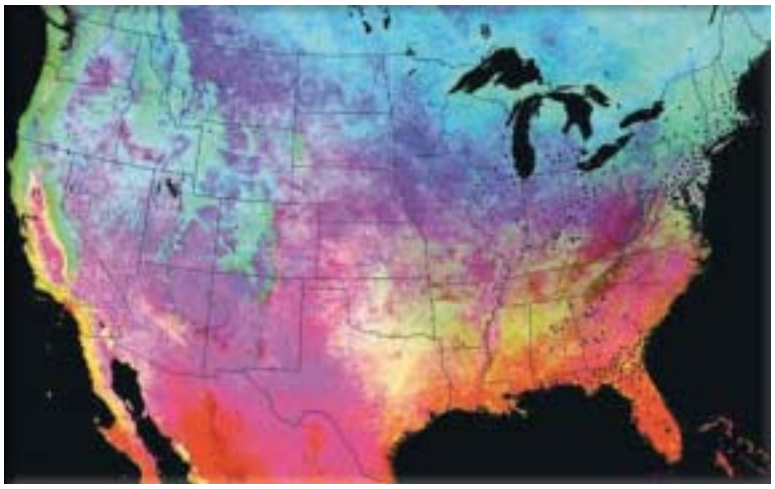
Challenges. From 2002 through 2012, NASA will increase the amount and scope of its remote sensing data. The challenge is to transition our observations and predictions to practical solutions that will help society. NASA will collaborate with other Federal agencies that can use our scientific and technological results. To facilitate this approach, a few key areas need to be addressed to benefit the Nation.

NASA and its partners need to share a common architecture for developing and deploying information solutions. The Climate Change Science Program Office at the U.S. Department of Commerce in support of the Administration's Climate Change Research Initiative recognizes this approach as important. Second, NASA and its partner agencies need to modify or develop information infrastructure between agencies so that our results can be incorporated into their decision-support tools. Finally, we must support the process of benchmarking the performance of candidate solutions integrated into decision-support tools.

Plans. The Applications Strategy and Applications Initiatives are based on partnerships with Federal agencies to develop three specific systemic solutions: establish a common architecture in order that other agencies can apply NASA's data in their operations, build capacity in decision-support tools for partner agencies, and validate and benchmark other agencies use of predictions and observations enabled by NASA research in their decision-support systems.

Strategic Objective 2. Stimulate public interest in and understanding of Earth system science and encourage young scholars to consider careers in science and technology

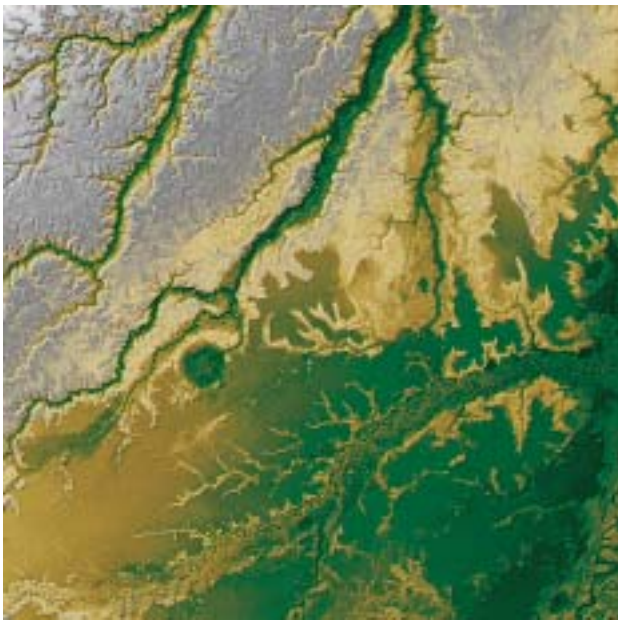
Achievements. A record 14 observation platforms orbited the Earth in the past year, creating an unprecedented demand for Earth science content, data, and expertise, which, in turn, supports the teaching and learning of science and math in the Nation's education system and enhances public literacy about science, technology, and the environment. The concept of the Earth as a rich



NASA tracks the spread of the West Nile Virus

Though not yet proven, scientists believe the West Nile Virus may be spread across the country by infected birds traveling along their migration routes. Mosquitoes, acting as vectors, transmit the virus when feeding on hosts such as birds, livestock, and people.

Satellite maps show nationwide temperatures, distributions of vegetation, bird migration routes, and areas pinpointing reported cases. The combined data help scientists predict disease outbreaks by showing where conditions are right for the insects to thrive and where the disease appears to be spreading.



NASA involves educators in a "high-impact" expedition

The 5-mile wide Iturralde Crater shown in this view of an isolated part of the Bolivian Amazon has a circular feature at the center-left that may have been caused by a collision with a meteor or comet between 11,000 and 30,000 years ago. In September 2002, NASA launched the second-ever expedition to this remote site.

Teachers from around the world who are involved with the Teacher as Scientist professional development program helped to design the expedition, and one teacher served as an on-site data collector. Bolivian university students also participated in the expedition. "The educational element of the expedition is just as important as the science results," said Goddard engineer Patrick Coronado. "This is one of those experiments that stirs the imagination, where science and technology come head-to-head with nature in an attempt to unlock its secrets."

and complex system of interconnected components and processes not only is a dominant paradigm in Earth science research but also underlies the core learning goals in the national and state education standards in science, mathematics, and geography. This underpinning, coupled with the Earth observations from orbiting satellites, readily allows students of all ages to experience Earth science as a process of inquiry, exploration, and discovery. The Earth Science Education Program met its objectives by continually developing quality curriculum-support materials, providing educators with compelling teaching tools and professional development experiences, supporting the development of exhibits and learning programs outside the classroom using multiple media, and training interdisciplinary scientists to support the study of the Earth as a system.

Challenges. Strategic partnerships are essential for NASA to achieve a systemic, scalable, and sustainable program that addresses education needs and influences learning. The challenges we face include creating a framework that enables system-wide solutions and optimizing the use of our existing resources.

Plans. Next year we will design a system architecture that improves the educational outcomes in a revolutionary rather than an evolutionary manner. The performance metrics for next year will include a description of the architecture; its implementation and associated management will be carried out in concert with the new Office of Education as part of NASA's core mission for education.

Strategic Goal 3. Develop and adopt advanced technologies to enable mission success and serve national priorities

The Advanced Technology Program consists of several project areas established to greatly reduce the risks associated with advanced instrument, measurement system, and information systems technologies that will be used in future science missions and user applications. With these investments, new measurements are attained, and existing measurements enhanced. Project areas range from concept studies to full space-flight demonstrations. Dozens of development efforts are underway at any point in time. As the technologies mature, they are inserted into aircraft science campaigns, space flight missions, and ground–information-processing systems. Program success metrics have been chosen to ensure that selection, development, and adoption of these technologies will enable or reduce the costs of future science missions and applications efforts.

For the past year, these project areas have successfully advanced 41 percent of the technologies in development at least one readiness level. The EO–1 advanced technology mission successfully demonstrated the use of a lightweight, low-cost, land imager prototype for future LandSat instruments. The EO–1 mission also validated a scientific quality, next-generation imager allowing scientists to discern unique spectral information collected as 200-plus bands of reflected energy from land scenes as a spacecraft passes overhead. The EO–1 successfully completed 100 percent of its validation objectives for nine technologies and is now available as a constant on-orbit high-technology test bed for the users. The technology development component of this goal met or exceeded all of its programmatic assessment metrics.

During this period, the Advanced Technology Program reached a level of maturity and productivity that evoked accolades from independent reviews held with the Technology Subcommittee of the Earth Systems Science and Applications Committee, an external advisory committee. In this strategic goal, we achieved five annual performance goals for a 71-percent success rate.

Strategic Objective 1. Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation

The EO–1 mission met its objectives of flight, validating breakthrough technologies for future Landsat missions.

Specifically, the EO–1 validated multispectral imaging capability for traditional Landsat user communities, hyperspectral imaging capability for Landsat research-oriented community needs (with backward compatibility), a calibration test bed to improve absolute radiometric accuracy, and atmospheric correction to compensate for intervening atmosphere. The EO–1 represents progress over the previous years as demonstrated by Hyperion and Atmospheric Corrector data, which are the first benchmark for non-DOD hyperspectral data. The EO–1 also validated six other advanced technologies. The public will benefit from the EO–1 technologies through future enhanced Landsat-type synoptic imaging of the Earth's land surface.

Following a comprehensive technology readiness assessment of laser-based remote sensing systems, NASA established a focused laser-lidar development program. Laser diodes are critical to the development of future Earth science laser-based instruments for the global measurement of ozone, water vapor, winds, carbon dioxide, and altimetry and trace gas constituents. Many NASA-funded programs experienced issues with laser diodes that affect future missions and technology development. In response, NASA established a Laser Risk Reduction Program to coordinate laser development at the Goddard Space Flight Center and the Langley Research Center. A working team developed a first-ever demonstration for double pulsing of a 2-micron diode-pumped laser system. This system is a crucial step in developing an eye-safe differential absorption lidar system, which will measure global carbon dioxide or winds from space. NASA researchers developed a multikilohertz microlaser altimeter, which uses high-repetition-rate laser altimetry with photon counting detectors. The instrument will cut costs and expand our Earth observation abilities. The project may be expanded to include a Shuttle laser altimeter in 2004 and a land/ice altimeter free-flyer after 2005.

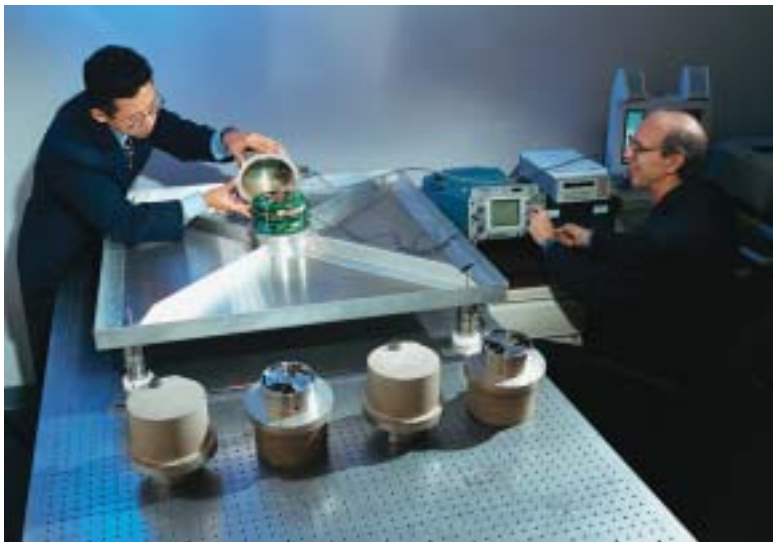
Six instrument technology projects appeared in the FY 2002 Earth System Science Pathfinder-3 round of proposals, with the ultra stable microwave radiometer instrument for measuring sea surface salinity included as part of the selected Aquarius mission proposal. The public will benefit from the success of this technology through the enabling of new measurements for sea surface salinity.

Challenges. Technically, the principal challenges are to enable the broad range of new measurements required by the science and applications research plans and to improve performance while reducing the cost, volume, mass, and power requirements of the measurement systems. Programmatically, the challenges are to ensure a short-, mid-, and long-range technology development plan consistent with the high-priority science and applications needs and to provide it within projected budget. The program must be robust and responsive to new technological discoveries and to science breakthroughs that might cause redirection or reprioritization.

The technical challenge requires developing sensor technology across the electromagnetic spectrum, from ultraviolet, visible, and infrared to the far infrared, sub millimeter, and microwave. There are challenges in both new passive and active sensor technologies. Two examples are space-flight lasers and large deployable microwave antennas.

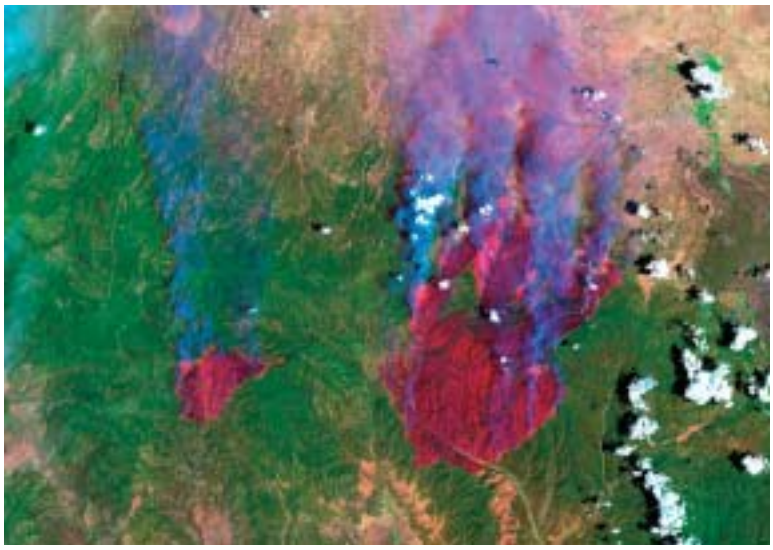
While space-flight lasers have been successfully flown, the technology is relatively new and difficult to replicate. In addition, new power technologies are needed to provide the higher power required by new measurements. Reliability problems associated with laser diodes remain a significant challenge.

To make passive microwave measurements of soil moisture from low-Earth and geostationary orbits, microwave antennas with much larger aperture are required. When current fabrication approaches are extended to these large



NASA studies lightning storms using uninhabited vehicles

Tony Kim and Dr. Richard Blakeslee of Marshall Space Flight Center in Huntsville, AL, test aircraft sensors that will be used to measure the electric fields produced by thunderstorms as part of NASA's Altus Cumulus Electrification Study.



NASA tracks the paths of merging wildfires

This image from the Landsat Enhanced Thematic Mapper Plus (ETM+) shows Arizona's Rodeo (right) and Chediski (left) Fires on June 21, 2002. In this false-color image, vegetation appears bright green and burned areas are deep red. At the time this image was acquired, the two large fires, one allegedly due to arson, and the other by a lost hiker, were still distinct, but over the course of two weeks, the two would merge into a single massive blaze. Landsat ETM+ captured the fires' succession over the next three weeks. Consuming almost half a million acres, the fire was the largest and most expensive fire in Arizona's known history, costing more than $30 million before it was contained.

apertures, they result in an antenna that is impractical because of it size and mass. This challenge may be met by sparse aperture approaches and/or lightweight, deployable structures. To enable these approaches, technology development of miniaturized components and lightweight structures is necessary.

Plans. NASA will aggressively pursue the laser-lidar efforts critical to future measurements. In addition, L-band interferometer synthetic aperture radar development will be proposed as a multiagency initiative. As a continuing effort, NASA will refine its ability to identify breakthrough technologies and to streamline methods for sustaining key developments from the component level to the subsystem level and on to a systems-level implementation. The effort to find the right balance of competitive and directed research will continue. Technology infusion efforts will be expanded. Collaborating outside NASA will be important.

NASA will further investigate techniques and identify critical technologies for operating and exploiting multiple spacecraft in cooperative constellations. This will include consideration of observation from multiple vantage points such as in geosynchronous orbits and at libration points along the Earth-Sun line.

Strategic Objective 2. Develop advanced information technologies for processing, archiving, accessing, visualizing, and communicating Earth science data

Achievements. The Earth Observing System Data Information Systems (EOSDIS) development is complete. It is an operational system. The system is operating far beyond its first conception more than a decade ago. The system was originally designed to support 10,000 Earth scientists conducting research and development. It served more than two million users in the past 2 years. Although the system was not conceived to be an operational computing system delivering data to millions of users nor to provide near-real-time turnaround of data, NASA has stepped up to the challenge of a massive increase in the system's user base. The system supports multiple satellites with single and multiple instruments, and will support more satellites in the future. The system currently supports the idea of formation flying and satellite constellations (for example, operating satellites in tandem such that their collective contribution is greater than their individual sum). NASA has planned for the growing demands on the system.

NASA is adding new systems and service capabilities through a build and test mode for system integration. NASA has released a Cooperative Agreement Notice and will select projects in the near future that will build and test new information system capabilities to form an Earth science research, education, and applications solution network. Competitively selected projects will work in concert with NASA's existing and emerging data and information systems by improving accessibility to an accurate, uninterrupted series of selected geophysical parameters that cover the 40-year record of Earth observations from space. The awarded projects will provide data products and tools to support the community in order to advance our knowledge of the Earth system, for resource management policy decision support in applications of national importance, and to provide interactive access to dynamically updated knowledge of the Earth system for decision makers.

Challenges. NASA needs to improve data-system responsiveness to changes in priorities, requirements, and technologies. We recognize that Government information systems no longer drive the business of systems development. The complexity and diversity of requirements precludes a simple commercial system purchase. NASA understands and agrees with leveraging off commercial hardware and software development, and will

make optimal use of commercial products as much as possible and feasible.

Plans. NASA is formulating a strategy for future efficient and flexible system evolution. The system was successfully fielded during a time of revolutionary rapid information technology change. NASA realizes the need to advance the system architecture. However, we need not start over. Concepts such as software reuse and open interface standards make technology infusion into a continually evolving network possible.

NASA is formulating the Strategic Evolution of Data Systems for use throughout this decade and to evolve the current system to a next generation. Future systems will ensure the timely delivery of Earth science information at an affordable cost, emphasizing flexibility to infuse new technologies. A future system is being formulated in cooperation with the NASA advisory committees and with the National Research Council. We will move to a number of smaller systems, incorporating new, innovative technologies such as processing aboard the satellites.

Strategic Objective 3. Partner with other agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction

Achievements. The productive use of NASA's remotely sensed data has greatly expanded because of successful partnerships with Federal agencies. NASA application project activities included collaborations with U.S. Geological Survey, U.S. Department of Agriculture, National Oceanic and Atmospheric Association, Federal Emergency Management Agency, Centers for Disease Control and Prevention, Environmental Protection Agency, and international partnerships with the Central American Commission on Environment and Development.

NASA is working with the U.S. Geological Survey to improve our ability to predict volcanic events. We are using our satellites to monitor conditions leading to volcanic eruptions. The organizations are moving from research to operations in the Earth-science-based solutions areas of land subsidence monitoring and biological invasive species. We are transferring an exploratory-class satellite to the operational community. NASA and the U.S. Department of Agriculture are collaborating on Earth science solutions for wildfire management, carbon management, precision agriculture, and global crop assessment and prediction. Finally, in conjunction with the Environmental Protection Agency, NASA is using Earth observations and predictions to support air-quality management decision-support tools.

Challenges. NASA and partner agencies must develop a coordinated approach to make the changes called for by the Climate Change Science Program Office. Enabling the systematic assimilation of remote sensing data and science-based predictions into practical solutions through partner-agency decision-support systems is critical to maximize the national investment in the Earth observing data, improve the quality of life, and serve society.

Plans. NASA is collaborating with partner agencies to develop 10-year roadmaps defining the specific remote sensing missions, Earth science models and predications that will be verified and validated for use in operational decision-support systems. The systems engineering functions undertaken by NASA will include rigorous benchmarking (systematic determination of performance improvements) of the effects of integrating Earth science results into decision tools for society.

Biological and Physical Research

MISSION: Use the synergy between physical, chemical, and biological research in space to acquire fundamental knowledge and generate biological and physical research

As humans make the first steps into space, we enter a new realm of opportunity to explore profound questions, new and old, about the laws of nature. At the same time, we enter an environment unique in our evolutionary history that poses serious medical and environmental challenges. NASA's biological and physical research addresses the opportunities and challenges of space flight through basic and applied research on the ground and in space. We exploit the rich opportunities of space flight in pursuit of answers to a broad set of scientific questions including research to address the human health risks of space flight as well as research to improve our understanding of the laws of nature.

NASA conducts research on the important changes the human body undergoes during space travel. These changes include significant health risks for space travelers. NASA seeks to understand these changes and the basic mechanisms behind them. We research methods to control health risks and to improve astronaut health and safety. This research often has applications to medical problems on Earth. For example, bone loss is experienced both by space travelers and by millions of aging Americans.

Just as the space environment presents challenges to our bodies, it presents challenges to the machines upon which we must rely in space. Research to enable safe and efficient human space travel includes research to improve the life-support systems that provide air and water as well as research on physical processes such as burning, boiling, and heat transfer. In the microgravity of space, smoke does not rise away from a fire, and bubbles tend to remain mixed within a boiling liquid. These and other novel behaviors pose specific challenges for designing spacecraft systems, and NASA conducts research to address those challenges.

The opportunity to conduct experiments in space allows researchers to control gravity and manipulate it as an experimental variable. NASA takes advantage of this opportunity to conduct research in the biological and physical sciences that cannot be conducted on Earth. We take advantage of microgravity to probe the basic process of life, and we exploit the novel environment of space to run new experiments including research on burning processes, on growing the tissues of the body in laboratory vessels, on the properties of new materials, and on the processes by which large molecules take their shapes. The opportunities for new research span disciplines from fundamental physics research on the basic properties of matter to applied research on the structure of target proteins for drug development.

These broad opportunities for research include research of direct interest to commercial enterprises. NASA works to encourage and enable commercial participation in space research by supporting commercially funded research on the Space Shuttle and the International Space Station.

Strategic Goal 1. Conduct research to enable safe and productive human habitation of space

NASA research addresses health issues created by radiation, microgravity, and isolation associated with space travel. More than 40 years of human space flight has produced a significant body of knowledge about the effects of space on human health. Profound changes occur in muscles and their strength and in bones and their hardness. The ability of the heart and blood vessels to carry out their normal functions is affected by the reduction of gravity, and the structure and function of brain circuits are altered and cardiovascular reflexes are changed. Basic body functions such as immune function, susceptibility to infection, and nutrition undergo significant changes. These effects must be explored in a systematic, scientific program in order to understand their long-term consequences and to develop appropriate countermeasures; otherwise, they will fundamentally limit humankind's ability to utilize space and explore the solar system.

The primary goal of this research is to improve health and safety for space travelers; however, this research also has the potential to make significant contributions to medical care on Earth. For example, space flight can provide models for exploring osteoporosis and other diseases of muscle and bone. It has provided unique insights into nerve regeneration and the capacity of the nervous system to grow, change, and adapt in response to environmental stimuli. The parallels between aging and space travel are under study by researchers at NASA and the National Institutes of Aging.

Strategic Objective 1. Conduct research to ensure the health, safety, and performance of humans living and working in space

Achievements. We conducted successful research on a method to reduce the risk of kidney stones in flight, successful tests of a drug to reduce the light-headedness and the inability to stand that can affect space travelers returning to gravity, and discovered suggestive new findings on the spinal cord and how reflexes change in space. Taken together, these and about 20 other ongoing investigations continue to expand our understanding of many physiological

changes associated with space flight and risks of space flight and the best methods for controlling them.

NASA researchers used historical data to identify cataract risks from space radiation and a statistical approach for defining the uncertainties in space radiation cancer risks was developed that will allow for new research approaches to risk assessment and mitigation to be evaluated.

We made significant progress on a radiation protection plan for improved astronaut health and safety. Under the auspices of the Station's Multi-lateral Medical Operations Panel, mission termination dose limits were agreed to by the international partners. The National Council on Radiation Protection and Measurements has issued new recommendations on dose limits, which are being incorporated into the NASA medical requirements for astronauts.

NASA continued to improve technology for live support systems and reduce the mass required to provide future space travelers with air and water. Engineers calculate that a life-support system designed in 2002 would require 33 percent less mass than the life-support system currently in use on the Station.

Challenges. The primary challenges to progress in this objective are our limited access to space and the small number of research subjects. While the presence of a permanently orbiting Station crew represents an unprecedented research opportunity, there is still a substantial challenge in maximizing understanding from a small sample. A second major challenge is developing and maintaining a vigorous, balanced research program while the Station is still in development.

Plans. NASA research to ensure the health, safety, and performance of humans living and working in space is among the highest priority research planned for the Station. NASA will use the Station to characterize physiological changes, such as bone loss, muscle deconditioning, and radiation risks, and develop an evidence-based strategy to define innovative countermeasures. In the near term, research on the Station will benefit from a suite of research equipment for regular experiments. We will support this effort with a broader campaign of research on the ground. Regular research solicitations will support this effort.

Strategic Objective 2. Conduct research on biological and physical processes to enable future missions of exploration

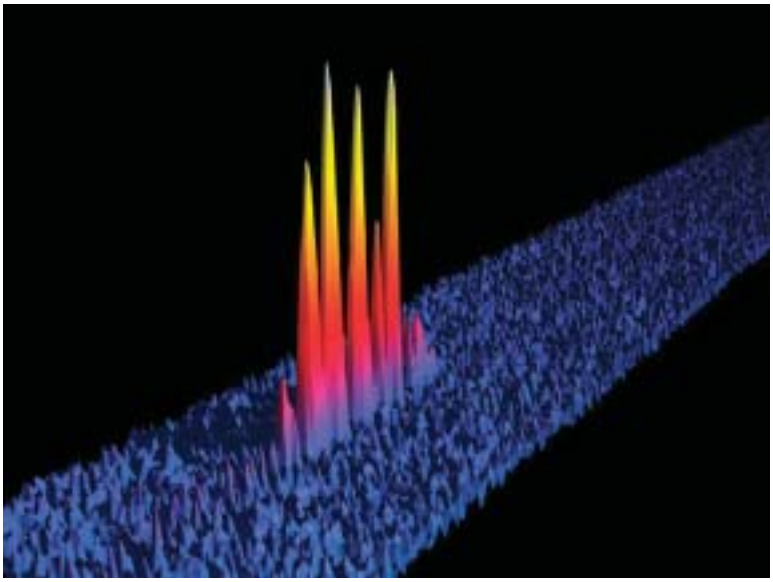
Achievements. Basic research in the biological and physical sciences is essential for future human exploration of space. Beyond reducing the cost and increasing safety for space travelers, this basic research promises to push the frontiers of knowledge and technology for Earth applications.

NASA and the National Cancer Institute are collaborating on biological and physical science research to support development of molecular level diagnostics for future missions of exploration. While NASA's medical objective is to ensure the health and safety of astronauts during long space flights, the National Cancer Institute's objective is to fight cancer through safe, painless early detection and intervention. Together, NASA and the National Cancer Institute developed and implemented an approach that first focuses on identifying important technologies and then generates joint program announcements (or solicitations) that target fundamental research within key technology areas. As partners in this program, NASA and the National Cancer Institute are united in their commitment to make this an applied program. That is, both results of the research and any products developed will be used to solve the independent, yet related life-threatening concerns both organizations face for the future.

NASA and the National Cancer Institute issued a Broad Agency Announcement for Fundamental Technologies for Development of Biomolecular Sensors. Awards were announced in the first quarter of FY 2002; NASA selected 7 extramural investigations for funding from a group of 55 proposals.

In parallel, NASA solicited proposals for the intramural program (restricted to NASA Jet Propulsion Laboratory and Ames Research Center), which focused on technology development closely aligned with NASA's exploration goals. This solicitation resulted in 16 selections. Summaries that include a description, the innovative claims and NASA significance, and plans are available for all Extramural and Intramural projects on the NASA-National Cancer Institute Biomolecular Sensor Development Web site. On June 24, 2002, the National Cancer Institute released the second joint announcement, Fundamental Technologies for Development of Biomolecular Sensors; the proposals were due November 1, 2002.

On the Station, an experiment was conducted to determine the effects of microgravity on photosynthesis and carbohydrate metabolism of wheat. Six on-orbit plantings, and seven on-orbit harvests of wheat were conducted during increment 4. The initial assessment of the data indicates that there was no difference in growth rate or dry mass of wheat grown on the Station. In addition, there was no difference in daily photosynthesis rates, leaf responses to canopy carbon dioxide concentration, or light intensity. This is the first replicated data obtained from plants grown under good environmentally controlled conditions to demonstrate that existing models using plants for advanced life support applications can be used without significant modification. While this has been the operating hypothesis for many years, the Station has provided the first opportunity to test directly this hypothesis in a scientifically credible manner.



NASA researchers observe a new atom wave phenomenon

NASA-funded physicists at Rice University discovered ultra cold atoms forming bright solitons, localized bundles of waves that maintain a constant shape as they propagate. The researchers observed atomic soliton trains, groups of as many as 15 solitons. These solitons propagated without spreading for several seconds—an eternity for a localized wave bundle.

This research may lead to technical innovations such as atom lasers that could eventually be used to predict volcanic eruptions on Earth and map a probable subsurface ocean on Jupiter's moon, Europa.

Challenges. NASA is working to produce a more integrated strategic plan to link physical science research with the Agency's strategic direction in a clearer manner. The related challenge is how to bring innovative technology to bear on the problems of space flight including reliability and performance on long missions. Because this research is on the cutting edge of biology, physics, and nanotechnology, the results are unpredictable.

Plans. NASA's collaborative effort with the National Cancer Institute will support development of next-generation instruments for molecular-level diagnostics for both space and Earth applications. NASA and the Institute have a common need for cutting-edge technologies. Their shared goal is to advance development of technologies and informatics tools for minimally invasive detection, diagnosis, and management of disease and injury. Future research will feature a more interdisciplinary approach and will include extending the database on radiation effects in materials using the newly commissioned Booster Application Facility at Brookhaven, conducting investigations on fire safety and microgravity combustion, and carrying out a microgravity heat exchange investigation on the Station.

Strategic Goal 2. Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology

The space environment offers a unique laboratory in which to study biological and physical processes. Researchers take advantage of this environment to conduct experiments that are impossible on Earth. For example, most combustion processes on Earth are dominated by the fact that hot gases rise. In space, this is not the case, and hidden properties of combustion emerge. Materials scientists study the role of gravity in important industrial processes. Physicists take advantage of microgravity to study exotic forms of matter that are better handled in space. Biological researchers investigate the role of gravity in life processes and how the space environment affects living organisms. Gravity's influence is everywhere. From the structure that gives steel its strength, to the structure of bone in a growing child, gravity plays an important role. In space, we enter a new realm of research in physics, chemistry, and biology. The results will provide important information and insight for improving industrial processes here on Earth.

Strategic Objective 1. Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community

Achievements. NASA increased the pace of the Station research to include research in fluid physics, combustion science, materials science, and biotechnology. Each Station research investigation exploits the space environment to explore questions that could not be explored on Earth. For example, researchers continue to be excited by results from experiments on colloids in space. Colloids are mixtures of very small particles suspended in a liquid—paint and toothpaste are both usually colloids. Physicists studying colloids in space are exploring the processes by which particles in colloids arrange themselves into regular patterns (crystal lattices). NASA hopes that colloid experiments in space will provide the critical information necessary to use colloids to make new materials on Earth, establishing the new field of colloid engineering. These processes are thought to be particularly important for developing three-dimensional photonic materials, optical switches, and components for future computers. Researchers report that they have been able to observe significant phenomena never before observed on Earth.

Breakthrough research on waves of ultra-cold atoms may lead to sophisticated atom lasers that might eventually predict volcanic eruptions or even map a probable subsurface ocean on Jupiter's moon Europa. The atoms were manipulated to form tidy bundles of waves, called solitons. They were created in a laboratory at Rice University in Houston, TX, under a grant from NASA's Biological and Physical Research Program through the Jet Propulsion Laboratory in Pasadena, CA. The researchers confined lithium atoms within magnetic fields, cooled them with lasers to one billion times below room temperature, and confined them in a narrow beam of light that pushed them into single-file formation. The atoms formed a type of matter called a Bose-Einstein condensate, a quantum state in which classical laws of physics are abandoned and new behaviors govern the atoms. The atoms join and function as one entity. The team actually observed a soliton train of multiple waves.

One of the first materials science experiments on the Station—the Solidification Using a Baffle in Sealed Ampoules—was conducted during Expedition 5 inside the Microgravity Science Glovebox. The glovebox is the first dedicated facility delivered to the Station for microgravity physical science research, and this experiment will be the first one operated inside the glovebox. Materials scientists want to make better semiconductor crystals to be able to further reduce the size of high-tech devices. To control the optoelectronic properties of the crystals, a small amount of an impurity—called a dopant—must be added to the pure semiconductor. Uniform distribution of the dopant in the semiconductor crystal is essential for production of optoelectronic devices. For this investigation, tellurium and zinc are added to molten indium antimonide specimens that are then cooled to form a solid single crystal by a process called directional solidification. The goals of this experiment are to identify what causes the motion in melts processed inside space laboratories and to reduce the magnitude of the melt motion so that it does not interfere with semiconductor production.

NASA successfully demonstrated its Avian Development Facility on STS-108. The Avian Development facility is designed to incubate 36 quail eggs in flight. Eighteen of the eggs are exposed to microgravity and 18 are spun in a centrifuge to simulate gravity. Researchers can use the developing quail embryos as models for exploring the effects of the space environment on growth and development. The initial flight of the facility focused on examining the growth and development of the balance system in the inner ear, as well as on the development of the skeleton. Bones from the quail eggs are being analyzed for changes in mineralization, cell-cycle timing, collagen synthesis, rate of bone formation, and the conversion of cartilage to bone during development. The inner ears are being analyzed to determine whether microgravity affects the development of balance organs, and what changes may take place in how they connect to the nervous system. The results from these investigations should yield fundamental insights into basic animal development and may lead to improved health care in space or on Earth.

Challenges. Biological and physical research in space is transitioning from a Shuttle-based research program to a research program focused on the Station. At the same time, issues associated with the Station development schedule and budget present challenges for research planning in a dynamic environment. This is true for fundamental biology research, which must continue to develop and support an excellent research community while the Station remains under development. Ongoing research operations and the continuing process of soliciting and selecting the highest quality research will remain the primary challenges within this objective. In addition, NASA continues to develop research facilities and scientific instruments for future use on the Station. These development challenges remain a focus of the program.

Plans. As the Station capabilities expand, NASA looks forward to a vigorous, peer-reviewed orbital research program supported by a strong ground-based program. Research on chemical, biological, and physical processes in the space environment is ongoing aboard the Station and will expand as Station capabilities expand. In the near term, research on the processes by which large molecules (macromolecules) crystallize will provide researchers with detailed three-dimensional data on proteins for drug development and biomedical research. Researchers will expand on investigations on colloids as model systems for self-assembling processes with applications in computer and communication technologies. NASA plans to conduct research that takes advantage of the unique environment of space to grow tissues outside the body for research and medical applications. We will focus on developing a strong research community prepared to use the research capability on the Station that will become available after 2004.

Strategic Objective 2. Develop strategies to maximize scientific research output on the Station and other space research platforms

Achievements. In FY 2002, a task force of the NASA Advisory Council performed an independent review and assessment of research productivity and priorities for the entire scientific technological and commercial portfolio of NASA's biological and physical research mission. The Council formed a Research Maximization and Prioritization Task Force that recommended a series of priorities across research disciplines. This review was based upon past performance in these disciplines as presented by the mission, as well as a review of a substantial body of existing reports from the National Research Council. The task force findings and recommendations rest on a large

foundation of work of hundreds of scientists who worked for thousands of hours, for months and years, to prioritize research within each biological and physical research scientific discipline. The committee successfully established a rationale and strategies for prioritization of the overall research program for the biological and physical research area and for the Station. The task force prioritized work that can be done on the Station with the U.S. Core Complete configuration and identified enhancements to the configuration that will enable a science-driven program of highest priority research. NASA's FY 2004 budget for biological and physical research focuses on research areas identified as high priority by the task force.

The National Research Council released prepublication copies of two related studies, "The Report of the Task Group on Research on the International Space Station" and "Assessment of Directions in Microgravity and Physical Science Research at NASA." Each report is consistent with the task force recommendations and strengthens our efforts to maximize research return from the Nation's investment in space.

Challenges. The Station is moving through an adjustment period. The program is working to implement the recommendations of the International Space Station Management and Cost Evaluation Task Force of the NASA Advisory Committee and is awaiting the near-term release of recommendations from both the Research Maximization and Prioritization Task Force of the committee and the Task Group on Research on the Station of the National Research Council. In their interim reports and communications, both the task force and the task group expressed concern over the limited availability of up-mass and crew time for research on the Station in its currently planned U.S. Core Complete configuration.

Plans. Implementing the Research Maximization and Prioritization Task Force priorities in the FY 2004 budget is a crucial first step in a longer running planning and prioritization process including 5-year and 10-year strategic planning. The biological and physical research mission responded to NASA's new strategic plan by adopting a 5-year direction consistent with overall agency vision, mission and goals. This direction identifies major research thrusts and the management changes required to support these thrusts. The biological and physical research mission developed a 10-year research plan that addresses its role within the NASA strategic plan by establishing a focused set of organizing questions and supporting top-level roadmaps that will drive the mission's research. The 10-year plan was drafted in consultation with outside advisers and will be subjected to additional scientific review. During the budget development cycle beginning in 2003, the biological and physical research area will engage its scientific community in developing more detailed interdisciplinary roadmaps, which will be guided by the 10-year plan. These roadmaps will form the basis for a biological and physical research strategic plan that will serve as the guiding document for future research solicitation, selection, and implementation in support of NASA's vision, mission, and goals.

Strategic Goal 3. Enable and promote commercial research in space

Ultimately, the solutions to the challenges of human space flight will open up new avenues of commerce. Dozens of commercial firms already conduct small-scale research projects in space. NASA provides knowledge, policies, and technical support to facilitate industry investment in space research. We will continue to enable commercial researchers to take advantage of space flight opportunities for proprietary research. The benefits of commercial research in space include improved products and services to enhance economic performance on Earth. In the long-term, economic activity in space will provide strengthened infrastructure for the exploration and development of space.

NASA helps Iowa firm build better soybeans

Peggy Whitson's face reflects in the cover of the Advanced Astroculture plant growth chamber as she inspects soybean plants. Whitson, the International Space Station's first Science Officer, dried the plants and beans, and the Space Shuttle Atlantis returned them to Earth. Researchers are studying the first-ever soybean crop grown on the Station to see whether it has unique, desirable traits.

Pioneer Hi-Bred International, Inc., a DuPont subsidiary based in Des Moines, IA, is the industrial sponsor for the experiment. To fly and analyze the beans, the company is working with the Wisconsin Center for Space Automation and Robotics at the University of Wisconsin in Madison. The center is one of 15 NASA commercial space centers. NASA's Space Product Development Program at the Marshall Space Flight Center manages the centers.

Strategic Objective 1. Provide technical support for companies to begin space research

Strategic Objective 2. Foster commercial research endeavors with the Station and other assets

Achievements. NASA supports and fosters commercial research in space through a network of commercial space centers. In FY 2002, these consortia attracted 2.7 times as much commercial funding in cash and in kind as they receive from NASA. Thirty-five new industrial partners were reported in FY 2002, easily surpassing the goal of 10. Companies identified are active in a variety of fields including agribusiness, biotechnology/biomedicine, advanced materials, and space technology/communication.

The commercial space centers continue to work with their industry partners to bring products into the marketplace. Two products were brought to market in FY 2002. The Space Rose fragrance product discovered on STS-95 by the Wisconsin Center for Space Automation and Robotics and their partner International Flavors and Fragrances was incorporated into a second product in FY 2002. The fragrance is now an ingredient in Impulse Body Spray and the variant Moon Grass marketed by Lever Faberge (part of Unilever); both products were introduced in January 2002 in the United Kingdom. Solidification Design Center Commercial Space Center affiliate Flow Simulation Services (Albuquerque, NM) began marketing software that will enable improved process design of particulate molding processes. The software Arena-flow is initially being marketed to the metal casting manufacturing industry, but future applications are being pursued in food and pharmaceutical production, aerosol drug delivery, and other biotech applications. Bioserve Space Technologies Commercial Space Center and its corporate partner, Amgen, Inc., conducted research on osteoprotegerin a drug in clinical trials for treating osteoporosis. This drug also may have potential for controlling bone loss in space. Positive results from a Shuttle experiment were presented at the annual American Society for Bone and Mineral Research conference in November 2002.

Challenges. The most significant challenge to commercial space research is timely and affordable access to space. With limited resources available on orbit and the Station in development, NASA's commercial partners face a difficult research environment. Non-NASA investment to the commercial space centers remained the same in FY 2002 as in FY 2001. Regular use of the Station for commercial research is only beginning.

Plans. As Station capabilities continue to expand, NASA looks forward to a vigorous commercial research program. NASA is incorporating a new set of research priorities in our plans. Researchers conducted several commercial experiments on the Station in FY 2002, and commercial research remains a significant fraction of the Station research planned for the near term. Specific areas include biotechnology, agribusiness, advance materials, and space and communications technology research. Successful research to date will encourage future partnerships by demonstrating that the Station is open for business. NASA expects increases in commercial investment over the next few years.

Strategic Objective 3. Systematically provide basic research knowledge to industry

Achievements. NASA supported three diverse conferences to expand interaction with the commercial research community: the National Association of Manufacturers conference in Chicago in March 2002; the Biotechnology Industry Organization annual meeting in Toronto, Canada in June 2002; and the NBC4 Technology Showcase in Washington, DC, in September 2002. In addition, several commercial space center representatives participated in a space forum in Colorado Springs, CO, in April 2002, where a number of useful contacts were made with industry. Business conferences highlighting biotechnology, materials manufacturing, and communication/technology development were all supported by commercial space center researchers describing the research they have done on the Shuttle and now the Station.

Challenges. The limited availability of commercial research opportunities remains a significant challenge as NASA works to expand commercial participation in space research.

Plans. NASA will integrate outreach to the commercial community with broader space research outreach goals. We will continue to seek venues for soliciting participation by commercial researchers.

Strategic Goal 4. Use space research opportunities to improve academic achievement and the quality of life

NASA supports academic research and programs to challenge young minds. We took pride in funding those who shared our enthusiasm for space- and ground-based exploration of space and science. NASA accomplished 100 percent of its annual performance goals in support of this strategic goal in FY 2002; we achieved the same score in the previous three years.

Strategic Objective 1. Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets

NASA gives students hands-on learning opportunities

Students from Lincoln West High School in Cleveland, OH, worked with NASA and University of California, Irvine scientists to load biological samples for an International Space Station experiment. In April, the Space Shuttle Atlantis delivered the samples, which thawed and formed crystals. The crystals were returned to Earth in June.

The primary purpose of these experiments was to grow crystals of biological macromolecules in the low-gravity environment of space. Researchers expected to improve their understanding of the three-dimensional and chemical structure of proteins, viruses, and nucleic acids. Knowledge of the precise three-dimensional molecular structure is an important component in biotechnology, particularly for protein engineering and rational drug design.

Achievements. Our educational outreach programs provided space research opportunities to educators and students in both formal and informal learning environments. The input of NASA scientists and engineers added great credibility and depth of content to these opportunities.

Five National Education Conferences attracted more than 70,000 teachers. The conferences featured NASA-sponsored workshops and demonstrations. In addition, we conducted hands-on activities that connect space research to classroom curricula and distributed numerous educational publications at each Conference's "One NASA" exhibit.

Challenges. Because of the varied life sciences, physical sciences, and commercial research efforts included in biological and physical research, this education and outreach program plays a strategic role in stimulating student and teacher interest in the fields of science, math, technology, and engineering. Our primary challenge is to communicate effectively with the educational community.

Plans. NASA continues to look for opportunities to use digital media to increase dissemination of materials, to meet the needs of varied learning styles, and to add companion pieces to our learning activities. We participate regularly at major education conferences and events, and we are expanding electronic outreach to educators. We will continue to seek opportunities for students to participate directly in space research.

Strategic Objective 2. Engage and involve the public in research in space

Achievements. In FY 2002, NASA continued to expand its outreach efforts to diverse communities. The Space Research newsletter highlighting physical, life science, and commercial research increased its production run from about 11,000 copies produced under the previous Microgravity News, focusing on physical science research, to more than 20,000 copies by the end of September 2002. The publication addressed all of the biological and physical research disciplines. NASA also participated in several professional conferences: the American Society of Clinical Oncology, the American Library Association, and the National Medical Association. A number of events are also planned for FY 2003. As part of our educational outreach efforts, NASA introduced in June a multimedia program on space research for educators to use in their school system after taking training in the multimedia program.

NASA and the Public Broadcasting System established a collaborative effort to produced a four-part television series and a complementing CD-ROM to provide an in-depth look at biological and physical science research. This project may reach a substantial audience ranging from kindergarten through grade 12.

Challenges. The primary challenge is to identify the diverse audiences making up the public sector: professional, technical, business, and the public; understand the needs and interests of these public sector communities; and develop outreach approaches that communicate the importance of NASA research.

Plans. NASA will continue to seek innovative approaches to bringing the experience of space flight to the public. A British media firm is exploring potential collaboration with NASA for a National Geographic-type film highlighting insect research in space. The discussion is very preliminary but may result in a productive collaboration.

Human Exploration and Development of Space

MISSION: To expand the frontiers of space and knowledge by exploring, using, and enabling the development of space for human enterprise

The space program is changing, perhaps forever, the frontiers of human presence and knowledge. Once earthbound, the frontier of human presence today is 250 miles above our planet. Once confined to what our telescopes could see through Earth's atmosphere, the frontier of our knowledge about the universe and its origins has expanded into the past millions of years. The discoveries and the opportunities of these changes inspire and challenge us. NASA's human exploration and development of space effort expands the frontiers of space and knowledge, exploring, using, and enabling space development. We achieve this through four strategic goals: expand the space frontier, enable humans to live and work permanently in space, enable the commercial development of space, and share the experience and benefits of discovery. Our strategic objectives include such long-term tasks as conducting research, developing new technologies, ensuring the health and safety of humans living in space, fostering private enterprise, and keeping the public apprised of our progress.

NASA completes 58th successful launch

On May 4, we launched Aqua, an Earth-observing satellite. It was the 58th successful launch out of 60 launches since 1987. This remarkable feat compares favorably with the average launch success rates over the same period for the U.S. Department of Defense and the U.S. commercial launch industry.

Strategic Goal 1. Explore the space frontier

Providing safe, reliable, and affordable access to space is a key element in realizing this goal. The five objectives for this goal pertain to technology development, engineering research, innovative mission designs, commercial development, and robotic missions. Four of the objectives do not have performance measures this fiscal year because they were related to the Technology and Commercialization Initiative. NASA cancelled the initiative because of a general funding reduction. The program was to conduct analysis for benefiting future safe, affordable, and effective human spaceflight projects that advanced science and discovery, human exploration, and commercial development of space. NASA transferred Technology and Commercialization Initiative funds to the Space Station Program in the fall of 2001. We successfully completed the remaining performance measure—enable human exploration through collaborative robotic missions.

In FY 2002, the human exploration and space effort also made substantial progress in meeting management challenges. The Agency established team of managers to coordinate a long-term plan for human and robotic exploration of space. We have defined requirements for the next generations of Earth-to-orbit and nuclear in-space transportation systems for the Integrated Space Transportation Plan and the Space Launch Initiative. We developed a scaleable, nuclear-thermal and electric propulsion system concept. We published the first guidance for integrating human requirements into mission and architecture designs.

Strategic Objective 3. Enable human exploration through collaborative robotic missions

Achievements. NASA uses the Space Shuttle and expendable launch vehicles to deploy spacecraft within and outside Earth's atmosphere. In FY 2002, we oversaw the launch and deployment of five scientific spacecraft and one communications spacecraft using commercial expendable launch vehicles. The communications spacecraft will provide high-data-rate communication links with the Shuttles, the Station, the Hubble Space Telescope, and other spacecraft.

Challenges. NASA's technical challenges in human exploration and development of space involve choosing the right launch vehicle and properly preparing the spacecraft for launch and deployment. We carefully manage the technical aspects of spacecraft and launch vehicles. When a failure occurs, we step back and study the events care-

fully to learn the cause and how to avoid similar failures in the future. This has improved mission success. Space exploration is inherently risky, and NASA's key challenge is to ensure that the process and practices we use remain focused on mission success.

Plans. We will continue to meet with the DOD and the U.S. launch industry annually to discuss strategies for mission success. Our performance goals for next year focus on investing resources to maximize successful launch and deployment. We will ensure that our employees have the skills and resources to make access to space safer, more reliable, and more affordable.

Strategic Goal 2. Enable humans to live and work permanently in space

Although U.S. and international astronauts are already living and working in space, achieving this goal would mean people could spend their lives away from our planet. The many steps to the goal are daunting but attainable. In FY 2002, we achieved most of the annual performance goals for this strategic goal.

Over the last 3 years, the performances of the Space Station, Space Shuttle, and Space Communications Programs have been remarkable. In FY 2001, the human exploration and development of space effort achieved seven of nine, or 78 percent, of its annual performance goals; in FY 2002, we achieved almost all of our goals. This trend resulted from hard work, attention to detail, and strong program management. Overall, it has been a very good year for progress toward enabling humans to live and work permanently in space.

Strategic Objective 1. Provide and make use of safe, affordable, and improved access to space

Achievements. The Space Shuttle Program accomplished four flawless missions in FY 2002, starting with Space Transportation System 108 (STS-108) and ending with STS-111. These flights supported construction of the Station, the delivery and return of crews, and Hubble servicing. Development of safety and supportability upgrades continues. These include cockpit avionics, engine health, landing gear tires, long-life alkaline fuel cells, and the altitude switch assembly. Modification of the Shuttle Discovery began in September. We also updated the prioritized list of infrastructure refurbishment, upgrade, and replacement candidates and associated funding. Infrastructure includes facility systems, ground support equipment, fabrication tooling, and equipment used to manufacture, test, process, and operate Shuttle flight hardware.

Challenges. The Shuttle Program faced several challenges in FY 2002. The number of flights was fewer than planned, primarily due to cracks detected in Shuttle Atlantis' fuel flow liner. Team members from across the Agency gathered to determine the best repair option and get the orbiters flying again.

We also cancelled the checkout and launch control system upgrade after assessments revealed that it was too expensive and its implementation schedule too uncertain. The upgrade would have modernized the Shuttle launch processing systems at Kennedy Space Center.

Plans. The Space Shuttle Program team will continue to maintain its commitment to safety. A portion of the checkout and launch control system funds will be redirected to the existing launch processing system, and civil servant employees will be assigned to other missions. In March, we began developing an integrated 2020 strategy for system design, hardware and software reliability, facility infrastructure, and personnel skills. Also, our Integrated Space Transportation Plan team is developing a strategy to select improvements to the Shuttles and next-generation vehicles. We will use common technologies where possible. The Shuttles will serve as a test bed for new vehicle technologies.

NASA performs Hubble "heart transplant" in space

On March 6, 2002, Astronaut John M. Grunsfeld worked in tandem with Astronaut Richard M. Linnehan to replace the Power Control Unit on the giant Hubble Space Telescope. Grunsfeld stands on a foot restraint on the end of the Space Shuttle Columbia's Remote Manipulator System.

Dubbed a "heart transplant" by the media, Hubble's electrical "heartbeat" was halted for the first time since the telescope's launch 12 years ago and then restored 4 hours and 24 minutes later. Rapid restoration was critical. Without electricity, the telescope could not protect itself against temperature extremes that could cause irreparable damage.

Strategic Objective 2. Operate the Station to advance science, exploration, engineering, and commerce

Achievements. The Space Station Program completed all planned research objectives in FY 2002 without on-orbit safety incidents. We launched utilization flight 1 in December 2001, assembly flight 8A in April 2002, and utilization flight 2 in June. Highlights of the flights included installing the 43-foot-long, 13.5 ton, truss—the backbone for future station expansion; installing the mobile base system on the mobile transporter, which allows the robotic arm to travel along the truss to work sites; replacing the wrist roll joint on the station's robotic arm; deploying Starshine 2, a student-tracked atmospheric research satellite for a heuristic international networking experiment; and honoring the victims of the September 11, 2001, atttacks by sending nearly 6,000 small U.S. flags into orbit as part of the "Flags for Heroes and Families" campaign.

Challenges. Space Station Program challenges include meeting research and science requirements, maintaining commitments to international partners, and completing remaining integration and assembly tasks by FY 2004, all within the constraints of the U.S. Core Complete Baseline, a three-person crew, limited number of flights, limited funding, and the requirements of international agreements.

Plans. Given these challenges, we are working closely with NASA's biological and physical research effort and the NASA chief scientist to support research priorities identified by the Research Maximization and Prioritization Task Force, an external advisory subgroup of the NASA Advisory Council. We have undertaken an activity to integrate Station research. The program continues to seek ways to increase research time within the constraints and is assessing options such as increasing flight rate and/or duration of visits to the Station. We will meet our safety objective while providing a minimum of 20 hours of crew research time each week plus the required telemetry. We will update power margin projections and coordinate power use options with the research community.

Strategic Objective 3. Meet sustained space operations needs while reducing costs

Achievements. In FY 2002, our ground and space networks delivered data at or above required levels for all NASA flight missions and missions of other Government agencies, international partners, and private companies. The Space Communications Program supported 4 Shuttle missions, around-the-clock Station operations, 15 expendable vehicle launches, and 30 sounding rocket launches. We also provided ground support for the Aqua and Mars Odyssey missions.

NASA expands the International Space Station

Astronauts Lee M. E. Morin and Jerry L. Ross, mission specialists on STS-110, put final additions on the installation of the station's new S0 truss segment. The 13.5-ton addition is the first segment of a structure that will ultimately expand the station to the length of a football field. The full truss will support new solar arrays and power management hardware on the space station. This will allow more research and more power-intensive experiments.

The first of three replacement tracking and data relay satellites became operational in 2002, as did a new demand access scheduling capability to increase the responsiveness and capacity for customers. The second replacement satellite launched in March 2002. We achieved cost savings in several areas:

- Centralized scheduling via the new Data Services Management Center, more automated data services, consolidated mission-data storage
- Re-engineering of wide-area network services for the Space Shuttle and Space Station Programs, including replacement of a domestic communications satellite circuit with a lower cost terrestrial circuit
- Elimination of unneeded communication circuits
- Increased use of commercial services for ground communications from Norway, South Africa, and Alaska.

Several efforts with educational institutions began this year, including the transferring mission services for two satellites to universities (Bowie State and University of California, Berkeley) and establishing a space communications contractor "storefront" at Prairie View A&M, University of Texas at El Paso, Oakwood College, and Alabama A&M. In FY 2002, the Space Communications Program conducted international

telemedicine demonstrations between doctors at the University of Mississippi Medical Center and Japan. The Space Communications Program also received a Federal Energy and Water Management Award at the Merritt Island Tracking Station.

Challenges. The Space Communications Program must continue providing high quality, cost-effective communications within NASA and to external customers, including ground network support to the Aqua mission.

Plans. Early contractor and civil service interaction will be necessary to ensure that the network is ready for upcoming launches, such as IceSat. Interaction between the Space Communications Program and the flight projects is just as important. To facilitate this, we will effect a distributed management process that accommodates the flight projects and maintains high quality, cost-effective communications. We will also pursue space communications partnerships with other Government agencies.

Strategic Goal 3. Enable the commercial development of space

Companies choose to locate or do business where they can serve customers and make a profit. Space offers many opportunities in this regard, but they must be carefully assessed by private companies that wish to take advantage of them. One of NASA's goals is to help companies gain the knowledge and experience to make those assessments. In 2002 we achieved four out of five annual performance goals related to enabling the commercial development of space. The successful goals involved providing an average of five middeck lockers on each Shuttle mission to the Station for research, establishing procedures that increase our use of the U.S. new commercial launch industry, continuing to implement Shuttle privatization efforts, and developing new collaborations with the private sector. The annual performance goal that was not achieved involves developing and executing a management plan and opening future station hardware and service procurements to innovation and cost-savings ideas.

Strategic Objective 1. Improve the accessibility of space to meet the needs of commercial research and development

Achievements. Middeck lockers provide stowage for research critical to completing Station mission objectives. In FY 2002, the Space Shuttle Program provided an average of eight middeck lockers for Station research. This exceeded our commitment to provide at least five middeck lockers. To date, 24 middeck lockers have been provided and planned research objectives have been accomplished.

Challenges. Our next Space Station Program challenges are meeting the research and science requirements, maintaining commitments to international partners, and completing the remaining integration and assembly tasks by FY 2004, all given the constraints of the U.S. Core Complete Baseline; the three-person crew, the limited number of flights, the limited funding, and international agreements.

Plans. We will continue to effectively manage crew time, middeck lockers, and up-mass (mass of the payload at lift-off), which are the three parameters critical for Station research. In FY 2003, we will work with the Station utilization community to maximize research. In preparation for the next solar array that will launch in early FY 2004, the Station will undergo many changes as new truss elements are attached and power channels are reconfigured. These reconfigurations will limit the power available for certain types of research, such as those requiring refrigeration. We have described the limitations to the utilization community and are identifying research efforts that do not require high power. After the next solar array is activated, sufficient power for research will be available. In the FY 2004 performance plan, performance measures for research power and telemetry (annual performance goals 2H10 and 2H17 in this year's Supporting Data section) will no longer be critical.

Strategic Objective 2. Foster commercial endeavors with the Station and other assets

Achievements. NASA began using a five-point management strategy that will achieve major Space Station Program objectives within funding limitations. In addition, we have begun using a new management information system that will strengthen the management and financial controls.

Challenges. Future Space Station Program challenges are meeting research and science requirements, maintaining commitments to international partners, and

NASA oversight ensures safe, successful missions

At NASA operation centers, we control launches and spacecraft (or payload) communications throughout the life of a mission. At the Payload Operations Center at Marshall, the International Space Station control team watches over the Station around the clock.

completing the remaining integration and assembly tasks by FY 2004, all given the constraints of the U.S. Core Complete Baseline, the three-person crew, the limited number of flights, the limited funding, and international agreements.

Plans. The new management strategy, as mentioned previously, has five focus areas. First and most critical is prioritizing the research plans upon which we will base the Station's final configuration. Second is completing of the U.S. Core Complete configuration. Third is implementing a reliable and effective cost estimating and management system to provide DOD-style independent cost estimates based on requirements whose costs can be accurately estimated. Already, the new strategy is improving cost estimates, bringing about management efficiencies, and refocusing staff for maximum accountability and performance. The fourth focus is identifying with our international partners areas where their role can grow. The fifth focus area is an overall assessment to ensure that logistics support is sufficient for safe, effective operations. In FY 2003, we will implement full cost accounting in accordance with the Integrated Financial Management Program.

Strategic Objective 3. Develop new capabilities for human spaceflight and commercial applications through partnerships with the private sector

Achievements. We extended the Space Flight Operations contract and began preparing a competitive sourcing plan. A NASA-commissioned task force of private sector business specialists lead by the RAND Corporation conducted an independent review of Shuttle operations and identified options for competitive outsourcing. In addition, we developed new collaborations with private sector companies that advance our exploration, research, and outreach efforts.

Challenges. The program management team is focused on maintaining the Shuttles' long-term safety and viability. Loss of NASA oversight because of contract consolidation and the resulting loss of NASA skills and experience could erode the program's critical checks and balances.

Plans. The management team will maintain program robustness by leveraging the talents of the NASA and private sector workforces. We will factor the RAND study findings and recommendations into our preliminary competitive sourcing plan for the Space Shuttle Program by February 2003.

Strategic Goal 4. Share the experience and benefits of discovery

We have a mission that fires the imagination and interest of the public. Both the Administration and Congress have encouraged us to use our discoveries, experiences, and popular position to spur students on to study science, engineering, and math. Our programs are ambitious, involving not only our professional outreach staffs, but also employee volunteers. We achieved 75 percent of the performance measures for this strategic goal.

Strategic Objective 1. Provide significantly more value to significantly more people through exploration and space development efforts

Achievements. NASA provided public access to a wealth of Station and Shuttle mission information, and public participation via the Web and exhibits such as the International Space Station Trailer and Destiny Module mockups. We participated in many educational, commercial, and political venues that provided hands-on opportunities for the public to learn more about the program. More than a half million people toured the mockups and

NASA gives students first-hand aerospace experience

Students from the University of Alabama in Huntsville, Alabama A&M University, and three Huntsville-area high schools prepare to launch the rockets they designed and built. The launch, which culminates more than a year's work, will demonstrate the student teams have met the challenge set by the Marshall Center's Student Launch Initiative: to apply science and math to experience, judgment, and common sense.

Marshall's Student Launch Initiative is an educational effort that aims to motivate students to pursue careers in science, math, and engineering. It provides hands-on, practical aerospace experience.

the visitor centers at Johnson, Kennedy, Marshall, and Stennis Centers.

Challenges. Translating the research and science objectives and accomplishments into tangible products that are meaningful to the public continues to be a challenge for NASA. Although not applicable to all research, the immediate benefits to the public are difficult to realize because of the long-term nature of the research projects and analyses. Breaking down communication barriers with the public is crucial to "inspiring the next generation of explorers." These are challenges that will be faced by the new NASA Office of Education.

Plans. We will transfer this metric but continue to support the new NASA Education Office by strengthening public knowledge and interest in NASA by arranging for public involvement in human spaceflight activities. In addition, we will develop an integrated Agency-wide system for tracking outreach performance across all spaceflight Centers.

Strategic Objective 2. Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets

Achievements. We improved our public Web sites and participated in numerous outreach events. Viewing opportunities for Shuttle launches further contributed to successful achievement of this goal. We provided educational opportunities to diverse formal education audiences (primary, secondary, and college educators and students). NASA spaceflight programs support more than 100 collaborative education efforts, including 7 science centers, museums, research labs, or observatories; 24 Government agencies and public organizations that support education; 32 colleges and universities; and 35 nonprofit, commercial, or mass media organizations.

Challenges. So far, we have no method for isolating the effect of our education efforts on improving scientific, technological, and academic achievement in our schools. In addition, most of our programs take place at the Centers; although each has regional outreach responsibilities, achieving a national scope with limited resources is problematic. Another area of concern is our ability to integrate our education efforts with the Government's education reform efforts (for example, No Child Left Behind).

Plans. In the coming year, we will support efforts to synchronize education activities across the Agency; strengthen education collaborations and partnerships; share resources among the Centers to support preservice teacher preparation programs and distance learning capabilities; and increase the number of student competitions that are so effective both in energizing students, schools, and communities and in enhancing NASA's research.

Aerospace Technology

MISSION: Maintain U.S. preeminence in aerospace research and technology

NASA's aerospace technology effort seeks to improve air and space travel, space-based communications, and high-performance computing through fundamental research and technology development. We focus on four strategic goals: (1) Revolutionize aviation—enable a safe, environmentally friendly expansion of aviation. (2) Advance space transportation—create a safe, affordable highway through the air and into space. (3) Pioneer technology innovation—enable a revolution in aerospace systems. (4) Commercialize technology—extend the commercial application of NASA technology for economic benefit and improved quality of life. (5) Space transportation management—provide commercial industry with the opportunity to meet NASA's future launch needs, including human access to space, with new launch vehicles that promise to dramatically reduce cost and improve safety and reliability.

Strategic Goal 1. Revolutionize Aviation—Enable the safe, environmentally friendly expansion of aviation

The aviation system is a complex amalgam of aircraft, airports, aircraft routing and safety mechanisms, such as air traffic control, the airspace itself, and the technologies, policies, and human factors underlying all of these. Expanding the system to meet demands for growth will mean making it more distributed, flexible, and adaptable. Any growth, however, must work within the physical and environmental constraints of today's system while anticipating and meeting the evolving needs of air travelers. What is more, the system is and will continue to be international in scope, requiring close coordination around the globe. Cleaner, quieter, and faster aircraft, with better performance and new capabilities, will operate in this new system. Advanced information and instruments will make air travel safer and more efficient. Air transportation will be easily accessible from urban, suburban, and rural communities. NASA aims to bring about this aviation expansion by delivering the technologies, materials, and operations needed for these new aircraft, information systems, and instruments. In FY 2002, the aerospace technology effort achieved 100 percent of its performance measures for this strategic goal.

Strategic Objective 1. Increase Safety—Make a safe air transportation system even safer

Achievements. In FY 2002, we examined aviation accident trends and identified technologies that will improve the safety of the national airspace system. In cooperation with the FAA and the aviation industry, we looked into accidents and incidents involving hazardous weather, controlled flight into terrain, human-performance-related causal factors, and mechanical or software malfunctions. We identified and assessed the situations and trends that lead to accidents. We then developed information technologies for building a safer airspace system.

These technologies include a self-paced, computer-based training program to help pilots detect, avoid, and minimize exposure to icing. The program explains the effects of icing on aircraft performance and describes how to detect and recover from icing-related wing and tail stalls (loss of lift). Ice accretion images from NASA's icing research aircraft and icing research tunnel, pilot testimonials, animation, case studies, and interactive demonstrations enhance the presentation. United States and European airline operators, Cessna Aircraft Company, Transport Canada, United Express, the Ohio Civil Air Patrol, and the U.S. Army Safety Center received copies of the program, which is also available online. Originally released in videotape in 2000, a computer-based training program for pilots of larger aircraft became available on compact disk in FY 2002 with additional training exercises and content for student pilots. We collaborated with the FAA, Air Line Pilots Association, and University of Oregon on this effort.

Several weather-related technology demonstrations took place in FY 2002. One, a forward-looking, turbulence-warning system, completed its 20th flight in NASA's commercial-transport-size research aircraft. The system's performance has been excellent, demonstrating an 81-percent probability of detecting severe turbulence more than 30 seconds before it happens and a nuisance alarm rate of only 11 percent.

In addition, we demonstrated software designed to help airlines schedule flight crews for long-haul flights. We based this scheduling assistant software on neurobehavioral, subjective, and operational measurements collected during commercial long-haul flights. The software predicts the effects of acute sleep loss, cumulative sleep loss, and circadian desynchrony (disruption of our normal 24-hour cycle) on waking performance. Airlines can also use this software to minimize practices that lead to in-flight fatigue.

Challenges. A fivefold reduction in the fatal aircraft accident rate is a national goal. NASA is contributing to attaining this goal by developing technologies that, if fully implemented, will reduce these fatalities by at least 50 percent. NASA is also a member of the Commercial Aviation Safety team, comprising aviation safety professionals from government and industry. However, NASA and the safety team are using different system analysis tools. The safety team projects a 77-percent reduction in

the risk of fatal accidents when new technology, training, and operational procedures come into full use. Our challenge is to work with the team to bring these disparate projections into alignment while we maximize the safety improvements available.

Plans. To address the disparate projections, we will assess aviation safety products using the Commercial Aviation Safety team's process and data sets and compare the results with our own process. Through this effort, we hope to help bring about a uniform assessment of progress toward the national goals. We will continue to develop critical technologies necessary to meet the aviation safety objective through flight tests and simulations.

Strategic Objective 2. Reduce Emissions—Protect local air quality and our global climate

Achievements. Among the chemicals produced by aircraft fuel combustion, two have the most significant effect on the environment. Nitrogen oxides degrade local air quality by creating smog and harm global air quality by contributing to ozone loss. Carbon dioxide degrades global air quality and contributes to global warming. NASA's efforts to minimize these emissions cover three areas: (1) minimize the effect of aviation operations on local air quality, (2) significantly or totally eliminate aircraft emissions as a source of harmful emissions, and (3) eliminate aviation emissions resulting from operational procedures. The following are highlights of the program's achievements in FY 2002:

The first tests of a low-emission aircraft engine combustor sector (a segment of a full combustor design) produced a nitrogen oxides reduction of 67 percent below 1996 International Civil Aircraft Organization standards. This result is just 3 percentage points short of our goal of a 70-percent reduction, 40 percent fewer nitrogen oxides emissions than current commercial aircraft engines, and 17 percent fewer than the combustor design we demonstrated last year.

A new ceramic thermal barrier coating increases the ability of turbine blades in aircraft engines to tolerate high temperatures. At higher temperatures, fuel burns more completely and with fewer emissions. Turbine blades, located directly behind the engine's hot combustor section, must withstand these high temperatures. NASA's coated test blades withstood temperatures 300 degrees Fahrenheit higher than standard blades. They survived 1,200 cycles (100 hot hours) at surface temperatures of 2,480 degrees Fahrenheit. This new coating will significantly increase the ability of both high-pressure turbine and combustor liner components to withstand high temperatures.

We completed two feasibility studies. One considered using fuel cells to power a state-of-the-art aircraft and predicts that such an aircraft would have a 54-nautical-mile range with a 140-pound payload. Fuel cell technology developments currently on the horizon may allow a fuel-cell-powered craft to exceed the payload and range of current piston-powered aircraft. The second study considered using liquid hydrogen to fuel a transport aircraft at today's state of the art, at 2009, and at 2022 technology levels and predicts that by 2022 hydrogen-powered transport aircraft could have a 52 percent lower gross weight at takeoff, lower nitrogen oxides emissions, and no carbon dioxide emissions while maintaining the same payload and range as conventionally powered aircraft.

Challenges. We must maintain emissions reduction technology performance as we impose increasingly demanding tests—from flame tube tests of concepts, to burner rig tests of combustor segments, to burner rig tests of full combustors. We must ensure that the technologies to reduce nitrogen oxides emissions do not increase carbon dioxide emissions and vice versa.

Plans. We will complete sector tests of our more mature combustor technologies and select some of them for further development and full configuration tests. We will also identify our most promising new technologies for further development.

Strategic Objective 3. Reduce Noise—Reduce aircraft noise to benefit airport neighbors, the aviation industry, and travelers

Achievements. Reducing aircraft noise near airports and, ultimately, confining the noise to compatible land-use areas around airports, will benefit homes and businesses near airports and, by reducing constraints on where new airports and runways can be located, enable faster and more efficient growth of the Nation's air system. NASA is conducting a balanced effort to make major advances in noise reduction by 2007 and looking to high-impact technologies to address the more difficult targets of 2022.

The following are highlights of the program's achievements in FY 2002:

System-level noise assessments are critical to determining which technologies have the highest potential for reducing community noise. A beta version software, the Advanced Vehicle Analysis Tool for Acoustics Research, shows great promise in providing these assessments. The software has all the prediction capabilities of NASA's Aircraft Noise Prediction Program and runs on the Linux operating system. It also corrects for propagation of jet noise, can predict noise from advanced high-bypass ratio engines and airframe subcomponents, and accounts for wind and temperature gradient effects on noise propagation. With these enhancements and its physics-based modeling capability, the software can allow designers to treat the various airframe and engine noise sources as an interrelated system and find the best set of components for noise mitigation.

Challenges. Noise-reduction technology needs to be available now if airplanes produced at the end of the decade are to be much quieter than today's. By 2010, most of the existing U.S. fleet will be nearing replacement. We should not miss the opportunity to influence the future noise impact of our air transportation system. Ensuring that the technologies we develop are actually used in future aircraft fleets requires that the technology matures adequately from subcomponent tests in the laboratory, to component tests in more realistic environments, to full integrated flight tests.

Developing and validating physics-based noise prediction models will allow us to more accurately assess engine and airframe noise-reduction technologies and changes in aircraft operations to reduce noise. In addition, the validated models will enable industry to assess and integrate these technologies into their products.

Plans. We will continue to develop and begin to validate the promising noise-reduction technologies we identified in FY 2002. Our programmers and engineers will complete initial physics-based prediction models of engine and airframe noise. We will evaluate, in an interim aircraft-level technology assessment, the potential for these promising concepts to reduce noise. The results from this analysis will provide a benchmark for measuring overall progress and guide future decisions. Work in 2003 will lay the foundation for efforts to reduce aircraft noise an additional 2 decibels below the 1997 baseline.

Strategic Objective 4. Increase Capacity—Enable the movement of more air passengers with fewer delays

Achievements. In cooperation with the FAA, NASA is developing airspace systems technologies through two paths: (1) The Advanced Air Transportation Technologies project develops decision-support technologies to help air traffic controllers and pilots use the airspace more efficiently. Techniques include reduced aircraft spacing, improved scheduling, and improved collaboration with operators. (2) The Virtual Airspace Modeling and Simulation project, new in FY 2002, will establish a virtual airspace simulation environment to test and evaluate new solutions to the Nation's aviation system problems. These technologies will increase the national airspace system's capacity to meet projected public demand and reduce delays without compromising safety. The following are highlights of achievements in FY 2002:

We conducted a simulation of the interoperability of two new graphical traffic automation tools: the Surface Management System and the Traffic Management Advisor. Both proved their worth to tower controllers, including the traffic management coordinator, from the Dallas Fort Worth airport. In the simulation, the coordinator used the tools to decide when to switch a runway from departures to arrivals. The coordinator found that the tools' timelines showing predicted arrivals and departures were the most helpful aid in determining when to change the runway configuration and in balancing departures.

The Traffic Flow Automation System, a decision-support tool for predicting traffic loads, was developed and evaluated. The tool tells controllers as much as a minute earlier than current tools how much air traffic will be entering their sector of the sky. The software, running on a Unix-based computer cluster, processed all of the air traffic in the national airspace system's 20 Air Route Traffic Control Centers simultaneously. The new tool predicts sector loading more accurately than the current tool and is 15 to 20 seconds faster.

Challenges. Our greatest technological challenge is the need to combine real-time analysis with fidelity to a complex system. Both aspects are essential if we are to accurately evaluate and select the air traffic management tools needed to achieve our goals.

Plans. The aerospace technology effort will complete development and validation of the advanced air transportation technologies in FY 2004. NASA expects these technologies to increase the capacity of the National Airspace System by 15 percent and controller productivity by 20 percent.

Strategic Objective 5. Increase Mobility—Enable people to travel faster and farther, anywhere, anytime

Achievements. New technologies to increase small aircraft safety in nearly all weather conditions can greatly increase the capacity of the nation's air system. The Small Aircraft Transportation System project will develop such technologies. In FY 2002, the Small Aircraft Transportation System project partners (NASA, the FAA, and the National Consortium for Aviation Mobility) began work to develop, evaluate, and demonstrate four new operating capabilities for small aircraft.

Challenges. The very fact of the many players in the public-private research and development collaboration described above poses a challenge to its effectiveness. The players are NASA, the U.S. Department of Transportation, the FAA, State and local authorities, universities, industry, and transportation service providers. The project must balance technology development, technology validation and demonstration, and technology assessment, and includes laboratory, simulation, and flight experiments.

Plans. NASA is applying its experience in the successful Advanced General Aviation Transport Experiments Program, which was also a public-private research and development collaboration, to the Small Aircraft Transportation System Program. The program will

demonstrate small aircraft operating concepts in flight tests over the next several years.

Strategic Goal 2. Advance Space Transportation—Create a safe, affordable highway through the air and into space

Revolutionizing our space transportation system to reduce costs and increase reliability and safety will open the space frontier to new levels of exploration and commercial endeavors. With the creation of the Integrated Space Transportation Plan, NASA defined a single, integrated investment strategy for all its diverse space transportation efforts. By investing in a sustained progression of research and technology development activities, NASA will enable future generations of reusable launch vehicles and in-space transportation systems that allow less costly, more frequent, and more reliable access to our neighboring planets and the stars beyond.

FY 2002 produced solid achievements in the development of space launch technologies. We achieved all of our annual performance goals. The Space Launch Initiative Program, after extensive analyses, narrowed architecture designs and conducted stringent systems engineering evaluations to ensure that selected designs will be viable and that our future technology investments are relevant to those designs.

NASA advances safe, reliable, and affordable space transportation propulsion

Advanced propulsion systems and hardware that are more reliable, safer, and less costly to build and maintain will enhance space commerce and enable more ambitious space science missions. "Safer" includes safer for the environment and for the people on Earth who maintain the systems. Shown here is the test firing of a reaction control thruster that uses nontoxic fuel.

Strategic Objective 1. Mission Safety—Radically improve the safety and reliability of space launch systems

Achievements. As noted above, the Space Launch Initiative Program narrowed its potential architecture designs—from hundreds to the 15 most promising—and aligned technology development investments to support them. Stringent systems engineering evaluations ensure that designs are viable and that technology investments are relevant. We have created an advanced engineering environment to analyze and validate data, to ensure that the Government is a smart buyer. Interrelated technology projects focus on such innovations as long-life rocket engines, robust thermal protection materials, and sophisticated diagnostic software. We have completed designs for a crew transfer/return vehicle and have several options for near-term development.

Propulsion is one of the keys to improving space access. We tested flight engine prototypes and components. A new liquid-oxygen/kerosene engine may afford quick turnaround and be fully reusable. An integrated vehicle health-management system demonstrates the potential to use model-based reasoning software to monitor the condition of the entire space launch system in every phase of operation.

Challenges. Our challenges include Level 1 (program-level) requirements validation—ensuring that we accommodate multiple users with a wide range of needs. The program must ensure that its cost estimate for development, operations, and the total system is credible. We must ensure that the technological payoff to NASA and the nation is enough to justify the resources and effort expended. We are coordinating a thorough review of the Level 1 requirements at the Agency level. We are refining cost models and employing innovative tools to control requirements and ensure that critical technologies mature early. We are also using a new design philosophy that focuses on total system operations.

Plans. Technology risk-reduction efforts will continue, as will architecture definition, technology development and evaluation, and systems engineering integration and analysis studies. The program has adopted a new focus on simplifying design that minimizes, eliminates, or streamlines all system interfaces. The focus includes operational activities and processes as well as hardware and software. We will continue to work with the DOD to incorporate military requirements for space access as appropriate. We will also continue to validate Level 1 requirements and subsequently will develop and validate system-level requirements.

Strategic Objective 2. Mission Affordability—Create an affordable highway to space

Achievements. The Space Transfer and Launch Technology Program is responsible for developing and

NASA demonstrates advanced composites processing

Composite materials offer many advantages over metals, including lighter weight and greater temperature strength. Composites are often costly to manufacture, however, as they require large vacuum chambers and heating equipment. Researchers have devised composites that can be processed in vacuum bags in an oven, somewhat like the boil-in-a-bag process (without the boiling water) we use at home. The results showed excellent adhesive strengths. Using this process will allow manufacturers to use existing equipment and less energy while producing a material that both performs better and is reusable.

demonstrating technologies for third-generation reusable launch systems. The objective is to identify systems to meet national mission requirements for space access and to develop the necessary technologies by the end of the next decade. In general, the engine demonstrator projects (rocket-based combined cycle and turbine-based combined cycle), and the X-43C flight demonstrator will develop macro-technologies and define requirements for micro-technologies.

In FY 2002, the Space Transfer and Launch Technology Program completed critical tests and established partnerships with industry and academia. Materials scientists improved airframe materials, while research engineers established design requirements for the rocket-based combined-cycle engine. The X-43C vehicle's preliminary and systems-level requirements will provide the project's baseline goals, a decision that moves us closer to procuring X-43C demonstrator vehicles. We awarded two University Research Education and Technology Institute grants: the Universities of Maryland and Florida will each receive $5 million annually for work in airframe and propulsion technologies research.

Challenges. Challenges in FY 2002 included the need to deal with the fallout from the X-43A mishap that occurred in FY 2001 and the associated, unplanned alternative launch vehicle study. The X-43C project has closely monitored the activities of the mishap investigation board. A thorough, independent study has concluded that the Pegasus booster remains the most viable launch vehicle. In another challenge, the prohibitive long-term cost of modifying the aging B-52 flight test aircraft to preserve operability resulted in our decision to use the Lockheed-1011 owned by Orbital Sciences Corporation as the X-43C carrier aircraft. This change, while less costly in the end, incurred a cost of $8 million to the program.

Plans. System studies will screen launch vehicle options such as single-stage and two-stage to orbit, horizontal takeoff/horizontal landing, and vertical takeoff/horizontal landing. We will also screen fuel options, including hydrogen, hydrocarbon, and dual-fuels, and propulsion options, such as hypersonic airbreathing engines. These studies also encompass safety, reliability, and life-cycle cost.

Strategic Objective 3. Mission Reach—Extend our reach in space with faster travel times

Achievements. Research engineers demonstrated a 10-kilowatt ion engine, which is designed for use in nuclear electric propulsion systems. Such an engine, with its nearly constant propulsion, could greatly reduce trip times for interplanetary missions. The high-power ion engine with titanium ion optics had four times the power and a 62 percent greater specific impulse than the state-of-the-art ion engine.

Challenges. The primary challenge is to develop component technologies necessary for a flight-qualified, high-powered ion engine.

Plans. We will continue to develop this technology by testing the molybdenum ion optics on test-bed engines. Researchers will assemble and test new high specific impulse ion optics made of titanium. They will also test carbon-carbon ion optics designed by outside researchers through a grant.

Strategic Goal 3. Pioneer Technology Innovation—Enable a revolution in aerospace systems

Developing the aerospace systems of the future will require revolutionary system design and technology development approaches. Using technologies that are now in their infancy, developing knowledge needed to design new systems, and developing tools for efficient high-confidence design and development are the focus of NASA's aerospace technology effort. The technologies we develop will enable NASA to achieve its strategic objectives, supporting the collection, analysis, and distribution of currently unobtainable data about our planet and the universe. In FY 2002, we achieved all of the annual performance goals for the pioneer technology innovation strategic goal.

Strategic Objective 1. Engineering Innovation—Enable rapid, high-confidence, and cost-efficient design of revolutionary systems

Achievements. In FY 2002, we developed engineering tools and computational architectures to reduce system design and analysis time, link geographically distant researchers in collaborative environments, speed software verification, provide adaptive capabilities for flight control systems, reduce mission risk, and streamline mission operations.

Several demonstrations showed the potential of advanced engineering tools to reduce system design and analysis time and to streamline mission operations. Engineers rapidly redesigned a crew return vehicle (to bring back Station crews in emergency conditions) using a flight simulation environment while pilots provided real-time feedback on handling qualities. A high-performance computing algorithm allowed mission designers to generate a database of reusable launch vehicle concepts without extensive numerical simulation. This cut the time required to evaluate vehicle concepts from several months to a week and reduced design cycle time to less than one-third that of state-of-the-art techniques. An adaptive grid generator for computational fluid dynamics analysis decreased computation time by 15 times.

We developed a collaborative workspace to streamline mission operations for the Mars Exploration Rover. The workspace allows dispersed scientists, engineers, and mission operators to interactively develop mission plans and monitor mission status. Collaborative engineering environments could substantially reduce the time needed to conduct tests and plan mission operations.

We conducted a successful proof-of-concept demonstration for a goal-oriented autonomous architecture tool. This software allowed prototype Mars rovers to plan their own paths and determine ideal instrument placement. This software reduced the number of command cycles needed to direct the rover to reach objects of scientific interest. An intelligent flight control system using adaptive neural networks—an artificial brain that learns from experience improved aircraft performance and reconfigured the control system to maintain vehicle stability when failures occurred. Such intelligent systems will result in safer, more efficient flight.

Challenges. There are many challenges involved in making possible fast, high-confidence, cost-efficient design of new systems. These include integrating diverse engineering and computational tools from different organizations; managing risk throughout the system life cycle; verifying complex software and autonomous systems; modeling the interaction of new technologies in complex systems; and transitioning new engineering practices and tools to users. We can overcome these challenges by involving end users early in the development of new engineering tools and by identifying and analyzing all factors that could contribute to system risk.

The ongoing economic struggles in the information technology industry posed an additional challenge to many of the efforts associated with this performance measure. The downturn's dampening effect on the industry's research and development has left a larger than expected gap between commercial capabilities and our requirements, which led us to demand more from our own, already taxed, information technologists.

Plans. In FY 2003, we will develop processes for full life-cycle planning and design of aerospace systems; better ways to certify and implement aerospace systems; computational capabilities and knowledge bases for aerospace system design; and tools to model new vehicles under all operating conditions.

Planned activities will push the state of the art in two key risk management areas: organizational risk and software risk. We will develop an organizational risk model for decision-support tools for complex operations. We will establish two new software test beds for software risk management and reliability. To demonstrate certifiable program synthesis technology, we will develop algorithms to automatically generate software designs and code based on requirements and specifications. This will include the development of autocoding technology that enables product-oriented certification, rather than certification for flight based on traditional methods. These innovations will make aerospace systems safer, more reliable, and more affordable.

Strategic Objective 2. Technology Innovation—Enable fundamentally new aerospace system capabilities and missions

Achievements. In FY 2002, we developed technology to make possible high-data-rate space communications from small ground stations, to provide advanced aircraft with simplified high lift systems using active flow control, and to demonstrate nanotechnology applications for chemical sensors and high strength composites.

The 622-megabit-per-second space communications link provides direct access to scientific data from satellites in low-Earth orbit using only a small, portable ground station. The ground station uses a digital modem and is about ¼ the size of the ground station presently required. This affordable way for users to communicate directly with spacecraft substantially reduces the time and expense needed to acquire and distribute data. These small ground stations can also supplement the existing space communications infrastructure to increase coverage or redundancy.

We demonstrated that an active-flow-control technology can improve lift and stability on advanced aircraft. Active flow control allows aircraft to use simpler high-lift systems that can reduce noise and allows transport-sized aircraft to access smaller airports. Because these systems are typically lighter, they can also reduce fuel use and emissions. In addition, a simulation demonstrated how flow control technology could affect aircraft stability. This flow control system used a porous wing, sections of which could reconfigure to maintain stability when other aircraft components failed. The porous wing may one day replace conventional control surfaces to reduce weight and improve safety.

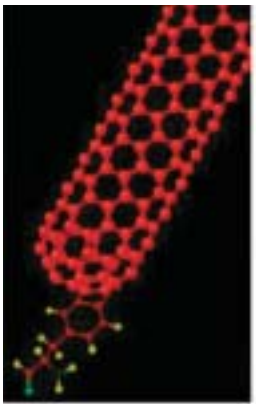
Nanotechnology (the art of manipulating materials on an atomic or molecular scale) may change our lives in a multitude of ways. NASA is engaged in nanotechnology research with potential applications to aeronautics and aerospace. For example, we demonstrated that it is possible to fabricate ultrasensitive chemical sensors from carbon nanotubes by attaching nucleic acids and other probe molecules to the nanotube's tip. When specific chemicals bonded with the probe molecule, a measurable change occurred in the nanotube. Potential applications for nanosensors include the search for life on other planets, medical diagnostics, such as detecting cancer cells and detecting biological and chemical threats to homeland security.

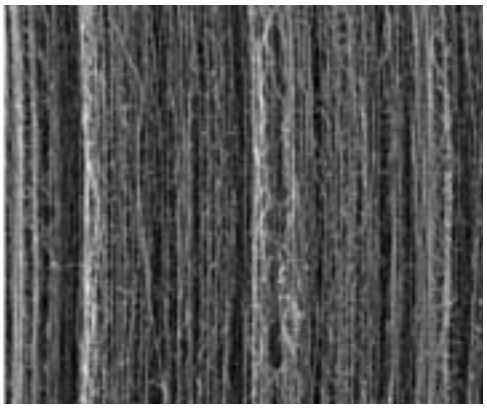
We also aligned carbon nanotubes in a polymer matrix by extrusion. This is an important first step in developing carbon nanotube-based composite materials. Nanotube fibers are usually produced in tangled bundles. Materials scientists believe that carbon nanotube-based composites with their fibers aligned in a single direction may be 100 times stronger than steel and ⅙ the weight. If these materials can be developed, they will significantly reduce the weight of aircraft, launch vehicles, and spacecraft.

Challenges. The challenges of enabling fundamentally new aerospace system capabilities and missions through technology innovation are many. We must look far ahead of current plans to create breakthrough ideas and identify high-payoff technologies. We must manage the long-term development of diverse technologies that may require 15 years from concept to application. And we must always be mindful of the transition of our technology products to the users who will infuse them into NASA missions.

Plans. We will develop ad hoc space communications networks in FY 2003. This will vastly improve science return by allowing NASA to deploy networks on demand to support space and planetary exploration assets. We will also demonstrate high power microwave sources capable of a two to three times increase in data transmission from Mars to Earth, and a 10 times increase from Earth orbit to ground. The power sources are based on traveling wave tubes and semiconductor power amplifiers. We may actually use these sources as early as 2005 for Mars mission communications.

NASA will also conduct a major demonstration of tools and techniques for intelligent data understanding. Specifically, we will finish developing feature recognition algorithms. This capability will greatly enhance our ability to extract patterns and other meaningful information from the vast amounts of data from space science and Earth science missions. In FY 2003, we will also simulate an autonomous science exploration mission, including demonstrating autonomy components operating independently during a mission. This is a key step toward spacecraft that can "think" for themselves and adjust to problems and opportunities during a mission.





NASA explores nanotechnology to improve chemical detectors and composite materials

Carbon nanotubes could be used to make ultra-sensitive chemical detectors to search for life on other planets, to detect cancer cells, or to provide early warning of chemical agents for homeland security. Carbon nanotubes could also provide very high-strength, low-weight materials for aerospace vehicles.

Strategic Goal 4. Commercialize Technology—Extend the commercial application of NASA technology for economic benefit and improved quality of life

This goal centers on extending commercial application of NASA technology to benefit the economy and improve quality of life. Although NASA technology benefits the aerospace industry directly, the creative application of our technology to disparate design and development challenges has contributed to other areas, such as the environment, surface transportation, and medicine. Commercializing and transferring NASA technology to U.S. industry, other Federal agencies, and other NASA programs involves the full range of our assets from expertise to research facilities.

All planned performance measures were successfully completed in FY 2002. We transferred a significant amount of aerospace technology to industry in 2002. In addition, our support of education continued to grow, featuring many educational materials and video productions. Customers using NASA facilities were, again this year, highly satisfied with the performance and quality of the services and with the support and expertise of NASA scientists and engineers.

Strategic Objective 1. Commercialization—Facilitate the greatest practical utilization of NASA know-how and physical assets by U.S. industry

Achievements. The aerospace technology effort transferred more than double the planned number of technologies to industry and other Federal agencies. Our exit surveys showed that more than 90 percent of customers

using NASA facilities were highly satisfied with the capabilities and support provided.

We have plans to develop educational products and increase public awareness of the benefits of NASA's aerospace technology research. Recent products include the following:

- The Aviation Safety Program Office's Single Aircraft Accident Prevention Project is featured in a new episode of the Distance Learning Program Destination Tomorrow, a news magazine format program targeted for adults. Three Kid's Science News Network scripts are ready for production. In these 1-minute vignettes, children instructors explain to children in kindergarten through second grade specific mathematics, science, technology, and computer science concepts. The program will be available in both English and Spanish. The Aviation Safety Program public Web site (http://avsp.larc.nasa.gov) provides much useful information and is regularly updated.
- Virtual Skies (for ages 9 to 12) is an interactive Web site that helps students explore the exciting world of aviation. It takes kids on a virtual visit of the NASA Ames Research Center to investigate the principles of flight, learn about flight planning, see large wind tunnels in operation, plot cross-country excursions, consider career opportunities, and much more.
- The Exploring Aeronautics CD-ROM (for students in grades 5 to 8) provides attractive, absorbing tutorials in the principles of flight and aircraft design. An online Web site introduces the CD-ROM, along with instructions on how to obtain it and how to incorporate it into a school's mathematics, science, technology, and geography curricula.

Challenges. In FY 2003, we will work to develop more efficient means of transferring our products to our technology customers in industry and Government. The challenge of understanding how to incorporate changes in technology-customer requirements in concert with high technical risk technology demonstrations is a continuous process between NASA and our technology customers

Plans. In addition to building on proven mechanisms, to transfer NASA technology to industry, we will increase efforts to inspire academic excellence in science, technology, engineering, and mathematics using educational products based on NASA aerospace technology research. Our outreach program will also strive to increase public awareness and understanding of the benefits of research and innovation. A special focus will be to support the Centennial of Flight celebrations.

Strategic Goal 5. Space Transportation Management—Provide commercial industry with the opportunity to meet NASA's future launch needs, including human access to space, with new launch vehicles that promise to dramatically reduce cost and improve safety and reliability. (Supports all objectives under the Advance Space Transportation Goal)

NASA technology saves lives

A Cirrus Airframe Parachute System, using technology developed by NASA, was deployed when the pilot experienced control difficulties. This marks the first time a certified aircraft has successfully landed with the aid of an airframe parachute.

Strategic Objective 1. Utilize NASA's Space Transportation Council in combination with an External Independent Review Team to assure Agency-level integration of near- and far-term space transportation investments

Achievements. In FY 2002, the External Requirements Assessment Team (ERAT) performed an independent review of the Second-Generation Launch Initiative requirements and architectures. The ERAT also actively participated in the interim architecture review.

Challenges. The Space Transportation Council disbanded in May 2002. However, the Integrated Space Transportation Planning team, the ERAT, the OIG, the GAO, and the NASA Office of Chief Engineer's Independent Program Assessment Office reviewed the Second-Generation Launch Initiative Program's progress.

Plans. We will continue to strive to improve our management practices by placing our management planning under the scrutiny of technically competent parties to ensure that our technology products will meet the needs of our customers.

Supporting Data

Space Science

Strategic Goal 1. Science: chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life

Strategic Objective 1. Understand the structure of the universe, from its earliest beginnings to its ultimate fate

Annual Performance Goal 2S1. Earn external review rating of green, on average, on making progress in the following research focus areas: Identify dark matter and learn how it shapes galaxies and systems of galaxies; and, determine the size, shape, age, and energy content of the universe.

The NASA space science effort achieved a rating of green for this annual performance goal. We re-evaluated our approach to our strategic goals and objectives and revised our annual performance measures for 2002. Therefore, a one-to-one match with previous years is not possible.

Indicator 1. Demonstrate significant progress toward the goal, as determined by external expert review

Results. For the focus area "identify dark matter and learn how it shapes galaxies and systems of galaxies," we achieved the following:

The Microwave Anisotropy Probe began science operations on October 1, 2001. It will perform the most sensitive all-sky study to date of the cosmic microwave background. Its data will be used to determine the amount of dark matter in the universe, and map how it shapes the sky distribution of systems of galaxies.

The Chandra X-ray Observatory measured the distribution of dark matter, on the smallest scale yet, in several clusters of galaxies and in an elliptical galaxy. The measurements imply that dark matter is not self-interacting in massive cosmic structures, narrowing the field of candidates for the enigmatic nature of dark matter, one of the most pressing questions in astronomy.

Data from the Hubble Space Telescope were combined with data from ground-based observatories to determine the dark matter mass of several galaxies. These galaxies are gravitational lenses that focus the light from more distant galaxies to reveal their mass distribution directly. These studies place limits on the relative amounts of normal and dark matter in galaxies.

Data from Chandra X-ray Observatory and the European Space Agency's XMM-Newton spacecraft were used to set a limit on the characteristics of a possible dark matter candidate—so-called sterile neutrinos. X-ray spectra from the Virgo cluster of galaxies rule out the possibility that the dark matter is in the form of sterile neutrinos with masses greater than about 1 percent of the mass of the electron.

An international team of astronomers observed a dark matter object directly for the first time. The Hubble and the European Southern Observatory's Very Large Telescope took images and spectra of a nearby dwarf star that gravitationally focuses light from a star in another galaxy. The result is a strong confirmation of the theory that a fraction of dark matter exists as small, faint stars in galaxies such as our Milky Way.

For the focus area "determine the size, shape, age, and energy content of the universe," we achieved the following:

On April 1, 2002, Microwave Anisotropy Probe completed the most sensitive all-sky map to date of the cosmic microwave background, the first of eight planned maps. Scientists will use the map, which is currently under analysis, to determine the basic parameters of the physical universe including size, shape, matter and energy content.

The Hubble has uncovered the oldest burned-out stars in our Milky Way galaxy. These extremely old, dim stars provide a reading on the age of the universe completely independent from previous methods. The ancient white dwarf stars, as seen by Hubble, turn out to be 12 to 13 billion years old, putting astronomers well within arm's reach of calculating the absolute age of the universe.

Scientists have used the Chandra X-ray Observatory measurements of x-ray emitting gas in clusters of galaxies to determine the matter and energy density of the universe. These results place a tight constraint on the mean total matter density of the universe and on the total density of dark energy in the universe.

Data Quality. The mission data and science outcomes accurately reflect performance and achievements in FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA's Space Science Advisory Committee delivers its findings directly to NASA management. Minutes of their meetings are located at http://spacescience.nasa.gov/adv/sscacpast.htm.

Performance outcomes are reported through normal mission reviews and are verified and validated by the program executive or program scientist. For descriptions of all space science missions that support this objective and example data, see http://spacescience.nasa.gov/missions/.

Indicator 2. Obtain expected scientific data from 80 percent of operating missions supporting this goal (as iden-

Annual Performance Goal Trends for Space Science

Annual Performance Goal	Performance Assessment			
	FY 1999	FY 2000	FY 2001	FY 2002
Strategic Goal 1. Science: chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life.				
Objective 1. Understand the structure of the universe, from its earliest beginnings to its ultimate fate.				
2S1				●
Objective 2. Explore the ultimate limits of gravity and energy in the universe.				
2S2				●
Objective 3. Learn how galaxies, stars, and planets form, interact, and evolve.				
2S3				●
Objective 4. Look for signs of life in other planetary systems.				
2S4				●
Objective 5. Understand the formation and evolution of the solar system and the Earth within it.				
2S5				●
Objective 6. Probe the evolution of life on Earth, and determine if life exists elsewhere in our solar system.				
2S6				●
Objective 7. Understand our changing Sun and its effects throughout the solar system.				
2S7				●
Objective 8. Chart our destiny in the solar system.				
2S8				◆
Objective 9. Support of Strategic Plan science objectives; Development/near-term future investments (Supports all objectives under the Science goal.)				
2S9				●
Strategic Goal 2. Technology/long-term future investments: develop new technologies to enable innovative and less expensive research and flight missions.				
Objective 1. Acquire new technical approaches and capabilities. Validate new technologies in space. Apply and transfer technology.				
2S10				●
2S11				●
Strategic Goal 3. Education and public outreach: share the excitement and knowledge generated by scientific discovery and improve science education.				
Objective 1. Share the excitement of space science discoveries with the public. Enhance the quality of science, mathematics, and technology education, particularly at the pre-college level. Help create our 21st century scientific and technical workforce.				
2S12	●	●	●	◆↑

tified and documented by Associate Administrator at beginning of fiscal year)

Results. The operating missions in support of this goal are Hubble Space Telescope, Microwave Anisotropy Probe, Chandra X-ray Observatory, and Far Ultraviolet Spectroscopic Explorer (FUSE). All four of the missions obtained expected scientific data in FY 2002, operating with very few unplanned interruptions. The FUSE spacecraft experienced a serious problem with its pointing system in December 2001. The problem interrupted science operations for 7 weeks until a heroic engineering effort successfully restored the mission to productivity.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are obtained from normal project management reporting and are verified and validated by the program executive or program scientist. For descriptions of the space science missions that support this objective, see http://space-science.nasa.gov/missions/.

Strategic Objective 2. Explore the ultimate limits of gravity and energy in the universe

Annual Performance Goal 2S2. Earn external review rating of green, on average, on making progress in the following research focus areas: discover the sources of gamma ray bursts and high-energy cosmic rays; test the general theory of relativity near black holes and in the early universe, and search for new physical laws, using the universe as a laboratory; reveal the nature of cosmic jets and relativistic flows.

The NASA space science effort achieved a rating of green for this annual performance goal. We re-evaluated our approach to our strategic goals and objectives and revised our annual performance measures for 2002. Therefore, a one-to-one match with previous years is not possible.

Indicator 1. Demonstrate significant progress toward the goal, as determined by external expert review

Results. For the focus area "discover the sources of gamma-ray bursts and high-energy cosmic rays," we achieved the following:

The High Energy Transient Explorer, the first satellite dedicated to spotting these frequent yet random explosions that last for only a few seconds, detected a rare optical afterglow of a gamma ray burst, the most powerful type of explosion in the universe. Armed with the satellite-derived localization, the Palomar 200-inch telescope spotted the afterglow and measured its red shift, which is used to calculate distance. The afterglow was also observed using the very large array of radio telescopes and by a NASA-funded robotic telescope in Tucson, AZ.

NASA scientists have analyzed more than 1,400 gamma ray bursts from the Compton Gamma Ray Observatory. Although most gamma ray bursts occur in the distant universe, billions of light-years away, analysis indicates that a small fraction may occur within 325 million light-years of the Earth. These nearby events may represent a new subclass of gamma-ray bursts and could be a source of detectable gravitational radiation. Their presence could explain the existence of ultrahigh-energy cosmic rays.

The Trans-Iron Galactic Element Recorder scientific balloon experiment set a new flight record of almost 32 days after completing two circuits of the South Pole. The balloon searched for the origin of cosmic rays, atomic particles that travel through the galaxy at near light-speeds and shower the Earth constantly. It is the first experiment that has both the collecting power and resolution to measure all nuclei from iron through zirconium, and, through those measurements, it will determine whether a cosmic-ray source is hot or cold, gas or solid.

For the focus area "test the general theory of relativity near black holes and in the early universe, and search for new physical laws using the universe as a laboratory," we achieved the following:

Observations of two neutron stars by Chandra may be inconsistent with standard models of nuclear matter. One possible explanation is that the two stars (one too small, the other too cool) may be composed of "strange quark matter," a form of matter more dense than an atomic nucleus. If confirmed, this would be the first detection of naturally occurring strange quark matter in the universe.

With Chandra, astronomers have detected features that may be the first direct evidence of the effect of gravity on radiation from a neutron star. This finding, if confirmed, could enable scientists to measure the gravitational field of neutron stars and determine whether they contain exotic forms of matter.

Scientists have found new evidence that light emanating from near a black hole loses energy climbing out of a black hole's gravitational well, a key prediction of Einstein's theory of general relativity. This observation of warped space, made with Chandra and the European Space Agency's XMM-Newton satellite, offers a novel glimpse inside the chaotic swirl of gas called an accretion disk that surrounds a black hole.

A pulsar observed with the Rossi X-ray Timing Explorer (RXTE) appeared to glitch seven times more frequently than any other known pulsar. These glitches, a term given to the sudden change in pulsar spin, are revealing the strange physics of the high-pressure interior of the pulsar.

Using RXTE, NASA scientists have observed a rare thermonuclear explosion on a neutron star that brightened it for so long that they could detect the orbital period of the star's companion and its spin frequency. These observations help us determine the mass and radius of the neutron star, and thus the equation of state for nuclear matter.

For the focus area "reveal the nature of cosmic jets and relativistic flows," we achieved the following:

Using Chandra X-ray Observatory to observe the x-ray jet in a distant quasar, scientists have derived information about the supermassive black hole at the center of the quasar. The x-rays from the jet are likely due to the collision of microwave photons left over from the Big Bang with a high-energy beam of particles. The length of the jet and the prominent knots of x-ray emission observed suggest that the activity in the vicinity of the central supermassive black hole is long-lived but may be intermittent, perhaps due to the mergers of other galaxies with the host galaxy.

Using a NASA instrument on the European Space Agency's XMM-Newton satellite, an international team of scientists has seen energy being extracted from a black hole for the first time. The observation may explain the origin of particle jets in quasars. According to the theory, rotational energy can be extracted from the black hole as its rotation is braked by magnetic fields. The Blandford-Znajek theory implies that energy flows to particle jets emanating perpendicularly from the accretion disk in supermassive black hole systems.

Results of studies of gamma-ray bursts with the High Energy Transient Explorer–2 and ground-based optical and radio observatories lend credence to theories that some gamma ray bursts come from the collapse of massive stars. Some of the observed emission comes from shock waves caused by relativistic outflows from the collapse colliding with material remaining from the precursor star's stellar wind.

Data Quality. Mission data accurately reflect performance and achievements in FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA's Space Science Advisory Committee delivers its findings directly to NASA management. Minutes of their meetings are located at http://spacescience.nasa.gov/adv/sscacpast.htm.

Performance outcomes are reported through normal mission reviews and are verified and validated by the program executive or program scientist. For descriptions of all space science missions that support this objective and example data, see http://spacescience.nasa.gov/missions/.

Indicator 2. Obtain expected scientific data from 80 percent of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year)

Operating missions in support of this goal are the High Energy Transient Explorer–2, the Rossi X-ray Timing Explorer, the Microwave Anisotropy Probe, and the Chandra X-ray Observatory. Each mission obtained all expected scientific data during FY 2002, operating normally with very few unplanned interruptions.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal project management reporting and are verified and validated by the program executive or program scientist. Descriptions of all of the space science missions that support this objective are located at http://spacescience.nasa.gov/missions/.

Strategic Objective 3. Learn how galaxies, stars, and planets form, interact, and evolve

Annual Performance Goal 2S3. Earn external review rating of green, on average, on making progress in the following research focus areas: Observe the formation of galaxies and determine the role of gravity in this process; establish how the evolution of a galaxy and the life cycle of stars influence the chemical composition of material available for making stars, planets, and living organisms; observe the formation of planetary systems and characterize their properties; and, use the exotic space environments within our solar system as natural science laboratories and cross the outer boundary of the solar system to explore the nearby environment of our galaxy.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results section of Part I.

Strategic Objective 4. Look for signs of life in other planetary systems

Annual Performance Goal 2S4. Earn external review rating of green, on average, on making progress in the following research focus areas: discover planetary systems of other stars and their physical characteristics; and, search for worlds that could or do harbor life.

The NASA space science effort achieved a rating of green for this annual performance goal. We re-evaluated our approach to our strategic goals and objectives and revised our annual performance measures for 2002. Therefore a one-on-one match with previous years is not possible.

Indicator 1. Demonstrate significant progress toward the goal, as determined by external expert review

Results. For the focus area "discover planetary systems of other stars and their physical characteristics," we achieved the following:

Astronomers using Hubble have made the first direct detection of the atmosphere of a planet orbiting a star outside our solar system and have obtained the first information about its chemical composition. Their unique observations demonstrate that it is possible to measure the chemical makeup of extrasolar planet atmospheres and perhaps to search for chemical markers of life beyond Earth. Hubble spectra of the planet as it passed in front of its parent star allowed astronomers to detect the presence of sodium in the planet's atmosphere.

The 2MASS spacecraft has revolutionized our understanding of the solar neighborhood with the discovery of nearby brown dwarfs. This led to the modification of the century-old spectral classification system and the systematic surveying of the solar neighborhood for all late-M, L, and T type field dwarfs and companions. Because the temperatures of these field objects are similar to those of very young brown dwarfs and planets, understanding their atmospheres is important to knowing how to look for recently formed planets.

For the focus area "search for worlds that could or do harbor life," we achieved the following:

Recently, exosolar planet hunters, using the Keck and other ground-based telescopes, announced the discovery of the first planet orbiting its star at a distance near or beyond the orbit of Jupiter in our own solar system. This planet combined with a known inner planet and suggestive evidence of yet a third planet in this system makes the star 55 Cancri the best-known analog to Sun and its planetary system. Perhaps most interestingly, the system possesses dynamically favorable conditions for the existence of an Earth-like planet, which remains elusive to

detection. NASA sponsored most of the research involved in this effort.

Data Quality. The mission data and science outcomes accurately reflect performance and achievements in FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA's Space Science Advisory Committee delivers its findings directly to NASA management. Minutes of their meetings are located at http://spacescience.nasa.gov/adv/sscacpast.htm.

Performance outcomes are reported through normal mission reviews and are verified and validated by the program executive or program scientist. For descriptions of all space science missions that support this objective and example data, see http://spacescience.nasa.gov/missions/.

Indicator 2. Obtain expected scientific data from 80 percent of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year)

Results. There were no space-based operating missions in direct support of this goal in FY 2002; however, the Hubble provided observations contributing to progress in this area (see indicator 1). The ground-based Keck and other telescopes also support discovery of other planetary systems. Future space-based missions in direct support of this research are expected.

Strategic Objective 5. Understand the formation and evolution of the solar system and the Earth within it

Annual Performance Goal 2S5. Earn external review rating of green, on average, on making progress in the following research focus areas: Inventory and characterize the remnants of the original material from which the solar system formed; learn why the planets in our solar system are so different from each other; and, learn how the solar system evolves.

The NASA space science effort achieved a rating of green for this annual performance goal. We re-evaluated our approach to our strategic goals and objectives and revised our annual performance measures for 2002. Therefore, a one-to-one match with previous years is not possible.

Indicator 1. Demonstrate significant progress toward the goal, as determined by external expert review

Results. For the focus area "inventory and characterize the remnants of the original material from which the solar system formed," we achieved the following:

The Stardust spacecraft started Interstellar Dust Collection Period 2.

Laboratory studies of the Tagish Lake meteorite indicate that it is the first sample of a D-type asteroid, one of the most primitive materials found in the solar system.

Kuiper Belt objects and short-period comets have different surface colors, which suggest different chemical compositions. This is intriguing because astronomers have thought the Kuiper Belt to be the source of the short-period comets.

Some Kuiper Belt objects are gravitationally bound binary systems; that is, two objects that circle each other as they circle the Sun. This provides insight into the collision processes in the Kuiper Belt.

The Comet Nucleus Tour (CONTOUR) spacecraft, which was to have conducted close-up investigations of two comet nuclei, was lost on August 15, 2002.

For the focus area "learn why the planets in our solar system are so different from each other," we achieved the following:

The Galileo spacecraft continued to make unique observations of Jupiter and its moons. Two recent flybys of the moon Io produced new results on the short time scales of surface modification due to volcanic eruptions and material deposition. Galileo detected an infrared hot spot and the tallest volcanic plume ever seen at Io, approximately 300 kilometers. The continued monitoring of the Jovian electromagnetic field effects on the ever-changing interplanetary environment adds to the understanding of the solar wind interaction with the giant planets and our knowledge about spacecraft survival under intense, varying conditions.

Measurement of climate and landscape dynamics on Mars from the Mars Global Surveyor and Mars Odyssey missions has illuminated how the evolution of the Martian surface and atmosphere differs from Earth's atmosphere. Both the Mars Global Surveyor and Odyssey have shed light on the distribution of volatiles on Mars. Recent results provide insight into the distribution of water on Mars and how subsurface reservoirs may interact with the atmosphere. For the first time, a global dust storm on Mars was observed from onset to completion.

For the focus area "learn how the solar system evolves," we achieved the following:

Research and analysis studies linked observations, laboratory experiments, and theoretical models to provide an increasingly sophisticated understanding of the evolution of solar system bodies. Other studies focused on how the planets have evolved within the overall context of the solar system.

Results from the Odyssey mission have mapped the regional distribution of water near the surface of Mars. Additional work will aid in evaluating if this reservoir is part of a greater subsurface aquifer or if it is more strongly coupled with processes of atmospheric exchange. Initial results from Odyssey also suggest that there is a greater diversity in the types of surface materials than previously thought.

The 26-degree tilt of Saturn's pole from its orbit is puzzling. It is much harder to tip over by a late impact than Uranus. Recently it was shown how the large angular momentum in Neptune's orbit can be coupled to the much smaller amount in Saturn's spin, greatly changing the direction of Saturn's spin vector, if the rates of precession of Saturn's pole and Neptune's orbit are integer multiples of each other—a resonance. Just such a resonance may have arisen in the early days of the solar system, as Saturn's nebula dissipated and Neptune moved outwards scattering comets into the Oort cloud along the way.

Data Quality. The mission data and science outcomes accurately reflect performance and achievements in FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA's Space Science Advisory Committee delivers its findings directly to NASA management. Minutes of their meetings are located at http://spacescience.nasa.gov/adv/sscacpast.htm.

Performance outcomes are reported through normal mission reviews and are verified and validated by the program executive or program scientist. For descriptions of all space science missions that support this objective and example data, see http://spacescience.nasa.gov/missions/.

Indicator 2. Obtain expected scientific data from 80 percent of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year)

Results. Operating missions in support of this goal are Stardust, Genesis, Cassini, and Submillimeter Wave Astronomy Satellite (SWAS). Each mission achieved its data collection and operation efficiency levels. Each mission obtained all expected scientific data in FY 2002, operating normally with very few unplanned interruptions.

Data Quality. The mission data and science outcomes accurately reflect performance and achievements in FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Performance assessment data are obtained from normal project management reporting and are verified and validated by the program executive or program scientist. For descriptions of the space science missions that support this objective, see http://spacescience.nasa.gov/missions/.

Strategic Objective 6. Probe the evolution of life on Earth, and determine if life exists elsewhere in our solar system

Annual Performance Goal 2S6. Earn external review rating of green, on average, on making progress in the following research focus areas: Investigate the origin and early evolution of life on Earth, and explore the limits of life in terrestrial environments that might provide analogues for conditions on other worlds; determine the general principles governing the organization of matter into living systems and the conditions required for the emergence and maintenance of life; chart the distribution of life-sustaining environments within our solar system, and search for evidence of past and present life; and, identify plausible signatures of life on other worlds.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results section of Part I.

Strategic Objective 7. Understand our changing Sun and its effects throughout the solar system

Annual Performance Goal 2S7. Earn external review rating of green, on average, on making progress in the following research focus areas: understand the origins of long- and short-term solar variability; understand the effects of solar variability on the solar atmosphere and heliosphere; and, understand the space environment of Earth and other planets.

The results of this annual performance goal and its associated indicators are located in the Highlights of the Performance Goals and Results section of Part I.

Strategic Objective 8. Chart our destiny in the solar system

Annual Performance Goal 2S8. Earn external review rating of green, on average, on making progress in the following research focus areas: understand forces and processes, such as impacts, that affect habitability of Earth; develop the capability to predict space weather; and, find extraterrestrial resources and assess the suitability of solar system locales for future human exploration.

The NASA space science effort achieved a rating of blue for this annual performance goal. We re-evaluated our approach to our strategic goals and objectives and revised our annual performance measures for 2002. Therefore, a one-to-one match with previous years is not possible.

Indicator 1. Demonstrate significant progress toward the goal, as determined by external expert review

Results. Understand forces and processes, such as impacts, that affect habitability of Earth.

Between October 1, 2001, and July 1, 2002, scientists discovered and catalogued 78 near-Earth objects with diameters greater than 1 kilometer. Almost all of these discoveries were through search efforts supported by the Near-Earth Object Observations Program. The total population is about 1,000 to 1,100 objects, of which more than 600 have been discovered and catalogued. NASA is on schedule to catalog 90 percent of near Earth objects greater than 1 kilometer in diameter by 2008.

For the focus area "develop the capability to predict space weather," we achieved the following:

Measurements by the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX) satellite show that, during large solar particle events, the geomagnetic cutoff for entry of energetic particles into the magnetosphere is often highly variable. These changes correlate well with changes in the geomagnetic activity. SAMPEX has shown that the actual cutoffs generally fall below calculated values and that the Earth's polar cap is larger than expected. During large solar particle events, the radiation dose at satellites such as the Station will be several times greater than expected.

The global ultraviolet imager on the Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED) spacecraft obtained images of equatorial plasma depletions. The images enable surveys of the extent and the distribution of large-scale plasma depletions. The depleted plasma structures are important because they significantly perturb, and even completely disrupt, electromagnetic signal propagation. In addition to causing abrupt communication outages, this phenomenon can also significantly affect Global Positioning System (GPS)-based navigation systems.

The Living With a Star targeted research and technology program supports a wide-ranging set of theoretical and empirical modeling designed to provide the framework for predicting space weather effects. Noteworthy studies include applying new methodologies for calculating and forecasting satellite drag; modeling the effects of solar energetic particles and galactic cosmic rays on cloud condensation in the stratosphere; characterizing the plasma environment responsible for spacecraft charging; identifying the conditions in the solar wind and within the magnetosphere that are responsible for the strong variability in the relativistic electron flux in Earth's magnetosphere; and developing new models and software tools for evaluating near-real time geomagnetic cutoffs.

For the focus area "find extraterrestrial resources and assess the suitability of solar system locales for future human exploration," we achieved the following:

Mars Odyssey observations indicate the presence of water near the surface of Mars, a potential resource for future explorers. Both Odyssey and the Mars Global Surveyor have identified localities that are potentially suitable for in-depth surface exploration, a necessary step for possible future human exploration.

Data Quality. The mission data and science outcomes accurately reflect performance and achievements in FY 2002. NASA's Space Science Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA's Space Science Advisory Committee delivers its findings directly to NASA management. Minutes of their meetings are located at http://spacescience.nasa.gov/adv/sscacpast.htm.

Performance outcomes are reported through normal mission reviews and are verified and validated by the program executive or program scientist. For descriptions of all space science missions that support this objective and example data, see http://spacescience.nasa.gov/missions/.

Indicator 2. Obtain expected scientific data from 80 percent of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year)

Results. There were no space-based operating missions substantially dedicated to supporting this goal in FY 2002. However, some operating missions have contributed to research in this area (see indicator 1). Future space missions are expected.

Strategic Objective 9. Support of Strategic Plan science objectives; Development/near-term future investments (Supports all objectives under the Science goal)

Annual Performance Goal 2S9. Earn external review rating of green on making progress in the following area: design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives.

The results of this annual performance goal and its associated indicators are located in the Highlights of the Most Important Performance Goals and Results segment of Part I.

Strategic Goal 2. Technology/Long-Term Future Investments: develop new technologies to enable innovative and less expensive research and flight missions

Strategic Objective 1. Acquire new technical approaches and capabilities. Validate new technologies in space. Apply and transfer technology

Annual Performance Goal 2S10. Earn external review rating of green on making progress in the following technology development area: Focus technology development on a well-defined set of performance requirements covering the needs of near-term to mid-term strategic plan missions.

The NASA space science effort achieved a rating of green for this annual performance goal. Because the focus of this goal resides in completion of specific milestones and development, once they are achieved, they are no longer a focus. Therefore, a one-to-one match with previous years goals is not possible.

Indicator 1. Meet no fewer than 66 percent of the performance objectives for technology development

- *Next Generation Space Telescope (NGST): Downselect to single Phase II prime contractor.*
- *Space Interferometry Mission (SIM): Use the Microarcsecond Metrology (MAM-1) test bed to demonstrate metrology at the 200-picometer level with white light fringe measurements. (Accomplishing this level of performance is required in order for SIM to identify multi-planet solar systems out to 10 parsecs.)*
- *Terrestrial Planet Finder (TPF): Provide studies and integrated models of mission architecture concepts.*
- *Gamma-ray Large Area Space Telescope (GLAST): Conduct Large Area Telescope Preliminary Design Review (PDR).*
- *Herschel Space Observatory: Complete the Spectral and Photometric Imaging Receiver (SPIRE) qualification model detectors.*
- *StarLight: Conduct Preliminary Design Review (PDR).*
- *Outer Planets Program: Complete evaluation and restructuring of Outer Planets Program.*
- *In-Space Propulsion: Compete and select Phase I award(s) for electric propulsion technology development.*
- *Living With a Star: Announce instrument investigations for Solar Dynamics Observatory mission.*

Results. We achieved seven of nine performance objectives for technology development, surpassing the required percentage for success in this metric. The Herschel Space Observatory did not complete the SPIRE qualification model detectors, and StarLight did not conduct a preliminary design review.

The Next Generation Space Telescope mission selected TRW, Inc. to design and fabricate the next-generation space-based observatory, named for NASA's second administrator, James E. Webb. Under the terms of the contract, TRW will be responsible for the design and fabrication of the telescope's primary mirror and spacecraft, and instrument integration, pre-flight testing, and on-orbit checkout.

Herschel experienced a delay due to a change in vibration requirements for SPIRE. The StarLight flight demonstration has been terminated, but the effort continues as ground-based technology development in support of formation-flying interferometry under the umbrella of the Terrestrial Planet Finder project.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data are from normal project management reporting and are verified and validated by the program executive or program scientist. For descriptions of the space science missions that support this objective, see http://spacescience.nasa.gov/missions/.

Annual Performance Goal 2S11. Earn external review rating of green on making progress in the following technology validation area: Formulate and implement cost-effective space demonstrations of selected technologies on suitable carriers.

The NASA space science effort achieved a rating of green for this annual performance goal. Because this goal involved completion of specific milestones and development stages, there is not a clear one-to-one match with 2002 goals and performance from previous years.

Indicator 1. Meet no fewer than 66 percent of the performance objectives for flight validation

Results. All but one performance objective were achieved. The flight validation for the New Millennium Program did not conduct the New Millennium Carrier-1 (NMC-1) confirmation review. The carrier was initially conceived for the experiments of Space Technology-6; however, none of the Space Technology-6 experiments required it.

The Space Technology-6 mission confirmation review was completed, and two technologies were selected to be flown. The Autonomous Sciencecraft Experiment is software designed to increase spacecraft decision-making capabilities for data processing, downlinking data, and identifying opportunities for interesting science observations. The Inertial Stellar Compass experiment is an ultra low power and low weight technology that will enable a spacecraft to determine its orientation whether it is spinning or stable. It will also enable a spacecraft to sense its position and recover its orientation after a power loss.

The Space Technology-5 mission completed critical design review and is now ready for manufacturing, testing and integration. Three miniature spacecraft, or nanosats, are scheduled to fly in a constellation to flight validate the technology that will improve scientific understanding of the Earth's high-altitude space weather.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data is retrieved from normal project management reporting and are verified and validated by the program executive or program scientist. For descriptions of the space science missions that support this objective, see http://spacescience.nasa.gov/missions/.

Strategic Goal 3. Education and Public Outreach: share the excitement and knowledge generated by scientific discovery and improve science education

Strategic Objective 1. Share the excitement of space science discoveries with the public. Enhance the quality of science, mathematics, and technology education, particularly at the pre-college level. Help create our 21st century scientific and technical workforce

Annual Performance Goal 2S12. Earn external review rating of green, on average, on making progress in the following focus areas: incorporate a substantial, funded education and outreach program into every space science flight mission and research program; Increase the fraction of the space science community that contributes to a broad public understanding of science and is directly involved in education at the pre-college level; establish strong and lasting partnerships between the space science and education communities; develop a national network to identify high-leverage education and outreach opportunities and to support long-term partnerships; provide ready access to the products of space science education and outreach programs; promote the participation of underserved and underutilized groups in the space science program by providing new opportunities for minorities and minority universities to compete for and participate in space science missions, research, and education programs; and, develop tools for evaluating the quality and impact of space science education and outreach programs.

NASA met or exceeded seven of the eight performance indicators for space science education and public outreach in FY 2002, earning an overall grade of blue for this metric.

Indicator 1. Meet no fewer than six (75 percent) of the eight performance objectives for education and public outreach

- *Ensure that every mission initiated in FY 2002 has a funded education and public outreach program, with a comprehensive education and public outreach plan prepared by its critical design review*
- *Establish a baseline for the number of space scientists who are participating in education and public outreach activities. This baseline will be used in the future to track success in increasing the fraction of the space science community that is directly involved in pre-college education and is contributing to a broad public understanding of science*
- *Plan and/or implement Enterprise-funded education and public outreach activities taking place in at least 40 states*
- *Ensure that at least 10 Enterprise-sponsored research, mission development or operations, or education projects are underway in HBCUs, HSIs, and TCUs, with at least 3 being underway in an institution of each type*
- *Provide exhibits, materials, workshops, and personnel at a minimum of five national and three regional education and outreach conferences*
- *Ensure that at least eight major Enterprise-sponsored exhibits or planetarium shows will be on display or on tour at major science museums or planetariums across the country*
- *Prepare the second comprehensive space science education/outreach report describing participants, audiences, and products for Enterprise education and public outreach programs*
- *Initiate a major external review of the accomplishments of the Space Science education and public outreach efforts over the past five years, and complete a pilot study directed towards the eventual development of a comprehensive approach to assessing the education and public outreach program's long-term effectiveness and educational impact. Use the preliminary results of both studies to guide adjustments in program direction and content*

Results. We exceeded the performance objectives in the following four areas: About 330 space science-funded education and outreach activities took place in all 50 states in FY 2002, greatly exceeding the metric of planning or implementing such activities in at least 40 states. The numbers of discrete events associated with such activities in FY 2002 was about 3,700. This is a more than 25-percent increase in the number of events reported in FY 2001.

NASA made history in FY 2002 by awarding the lead responsibility for a space flight mission, for the first time, to a Historically Black College and University (HBCU). Hampton University's Aeronomy of Ice in the Mesosphere (AIM) mission was one of only two missions selected through competitive peer review for future flight under the Small Explorers (SMEX) Program. This $92 million award dwarfs all previous NASA investments in HBCUs. Also in FY 2002, 15 minority universities, including (HBCUs), 3 Hispanic serving institutions (HSIs), and 3 tribal colleges (TCUs), continued work on space science development activities under the Space Science Minority University Initiative. Additional activities underway at minority universities in FY 2002 included continued funding of research grants to HBCUs and HSIs, continued operation of the FUSE mission through a ground station at the University of Puerto Rico at Mayagüez, and continued operation of a facility for launching scientific high-altitude balloons by New Mexico State University at Ft. Sumner, NM. Together, these activities greatly exceeded the FY 2002 metric of having at least 10 funded research, mission development or operations, or education projects underway at HBCUs, HSIs, and TCUs, with at least one being underway in an institution of each type.

We provided exhibits, materials, workshops, and personnel at 21 national and 15 regional education and outreach conferences in FY 2002. This greatly exceeds the FY 2002 metric of having such a presence at five national and three regional conferences.

The national education and outreach conferences at which there was a major space science presence in FY 2002 included:

- Association of Science-Technology Centers (October 2001 in Phoenix, AZ)
- American Indian Science and Engineering Society (November 2001 in Albuquerque, NM)
- International Technology Education Association (March 2002 in Columbus, OH)
- National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (March 2002 in New Orleans, LA)
- National Science Teachers Association meeting (March 2002 in San Diego, CA)
- Public Library Association (March 2002 in Phoenix, AZ)
- Civil Air Patrol's National Congress on Aviation and Space Education (April 2002 in Arlington, VA)
- National Council of Teachers of Mathematics (April 2002 in Las Vegas, NV)
- International Planetarium Society (July 2002 in Wichita, KS)
- Society for the Advancement of Chicanos and Native Americans in Science (September 2002 in Anaheim, CA).

The regional conferences with such a presence included two state library associations, seven state science teachers associations, and three National Science Teachers Association regional meetings, along with a number of other local or regional meetings.

The following major NASA-sponsored space science exhibits and planetarium shows were on display or on national tours at major science museums or planetariums across the country in FY 2002 included:

Exhibits included:

- Cosmic Questions: Our Place in Space and Time Exhibition (Boston, MA)—Explore the Universe Exhibition (Washington, DC)—Hubble Space Telescope: New Views of the Universe Exhibition—Large Version (Kennedy Space Center, FL; Kansas City, MO)
- Hubble Space Telescope: New Views of the Universe Exhibition—Small Version (Bridgeport, CT)
- MarsQuest Traveling Exhibition (Hickory, NC; Chicago, IL; Hampton, VA)
- Space Weather Center Exhibition (Chicago, IL; El Paso, TX; Belleville, MI)
- Voyage: A Journey Through Our Solar System Exhibition (Washington, DC)
- Journey to the Edge of Space and Time Planetarium Show (Boston, MA, and Philadelphia, PA)
- MarsQuest Planetarium Show (Arkadelphia, AR; Bowling Green, OH; Chicago, IL; Columbus, GA; Hastings, NE; Maryville, TN; Orlando, FL; Radford, VA; Richmond, KY; Toms River, NJ; Tucson, AZ)
- Northern Lights Planetarium Show (Berkeley, CA, and Champaign, IL).

In addition, ViewSpace provided more than a hundred institutions around the country—most of them small science centers or planetariums—with displays of continuously updated images from Hubble and other NASA space science missions. This exceeds the metric of having at least eight museum exhibits or planetarium shows on display or on tour in FY 2002. New for FY 2002 are "Voyage: A Journey Through Our Solar System," a scale model solar system installed on the National Capitol mall in Washington, DC, in October 2001, and "Cosmic Questions: Our Place in Space and Time," an exhibition inviting visitors to understand the universe and our place in the cosmos, which opened at the Museum of Science in Boston in September 2002. These exhibitions, and several others mentioned above, are direct results of collaborations with institutions such as the Smithsonian Institution and the National Science Foundation. These collaborations take advantage of the science content that is our primary resource and leverage it through the expertise of the Smithsonian in developing and exhibits and the funding available from the National Science Foundation for supporting such exhibits.

We met the performance objectives in the following three areas:

- A preliminary count shows that 895 space science mission affiliated space scientists, technologists, and support staff participated in education and public outreach activities in FY 2002. This sets a baseline for measuring future success in increasing the fraction of the space science community that is directly involved in pre-college education and is contributing to a broad public understanding of science. The FY 2003 metric calls for a 5-percent increase over the FY 2002 baseline.
- The second space science education and public outreach report describing participants, audiences, and products for the FY 2001 education and public outreach programs was made available in a searchable,

online version in May 2001 and in printed form in June 2001.

- A task force of the NASA Space Science Advisory Committee convened in April 2002 to begin examining and evaluating how well we have done in carrying out the education and public outreach program over the past 5 years and to determine whether any significant adjustments in the approach are needed. The task force held its final meeting in August 2002 and is now preparing its findings and recommendations. In addition, the Program Evaluation and Research Group at Lesley University in Cambridge, MA, submitted their interim report on assessing the long-term effectiveness and educational effect of the activity. The preliminary findings from both studies provided a very consistent picture. They indicated that we have a well-regarded education and public outreach program that needs several adjustments. The most significant of these are the need to develop more coherence in the program materials and to provide significantly more opportunities for professional development for the personnel charged with carrying out the program. These findings provide the major guidance for improving the program in FY 2003.

We were unable to examine each mission's plan because of a lack of staff. Thus, we did not meet the metric that every mission initiated in FY 2002 shall have a funded program with a comprehensive education and public outreach plan by the time of its critical design review.

Data Quality. The data cited are presented in the NASA Space Science Education and Public Outreach Annual Report, which is available at http://ossim.hq.nasa.gov/ossepo/. Further information on this NASA space science program is available at http://spacescience.nasa.gov/education/. The major limitation of these data is that they represent only activities, products, and events that were reported through the NASA space science tracking and reporting system. They are, therefore, undoubtedly incomplete and the numbers cited here represent minimum values.

Data Sources. The data cited are presented in the NASA Space Science Education and Public Outreach Annual Report, which is available at http://ossim.hq.nasa.gov/ossepo/. Further information on this NASA space science program is available at http://spacescience.nasa.gov/education/.

Earth Science

Strategic Goal 1. Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth

Strategic Objective 1. Discern and describe how the Earth is changing

Annual Performance Goal 2Y1. Increase understanding of global precipitation, evaporation and how the cycling of water through the Earth system is changing by meeting at least three of four performance indicators.

The overall assessment for this annual performance goal is yellow. Scientists used precipitation data sets to assess the effect of global warming and other temperature variations on rainfall. However, preliminary results proved unclear and further analysis was needed. Data analysis of polar and geostationary satellite observations provided a new perspective on the way moisture varies seasonally in both the Northern and Southern Hemispheres. It will take at least another decade to establish regional statistics of variability.

Indicator 1. Combine analysis of global water vapor, precipitation and wind data sets to decipher variations (and possible trends) in the cycling of water through the atmosphere and their relation to sea surface temperature changes

Results. NASA did not achieve the indicator. Precipitation data from the Tropical Rainfall Measuring Mission (TRMM) and other satellites assisted in assessing the effect of rain on global warming and other temperature variations. However, we did not combine global water vapor and wind data sets to decipher these variations. Preliminary results (see the example data source) indicated an unclear relation and further analysis was required.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The following is an example of a journal that published information about the indicator: Robertson, F. R., R.W. Spencer, and D.E. Fitzjarrald, 2001. A new satellite deep convective ice index for tropical climate monitoring: possible implications for existing oceanic precipitation data sets, Journal of Geophysical Research Letters, 28, 251-254.

Indicator 2. Analyze data from polar and geostationary satellites in a consistent fashion over at least two decades to evaluate whether the detectable moisture fluxes are increasing beyond the expected ranges of natural variability

Results. Researchers analyzed the data showing how moisture varies seasonally in both the Northern and Southern Hemispheres. Because the variability was so high, it will take at least another decade of observations to establish regional statistics.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The results and related publications in scientific journals are available at http://www.stcnet.com/projects/nvap.html and http://eosweb.larc.nasa.gov/.

Indicator 3. Determine the time and spatial variability of the occurrence of strong convection regions, precipitation events, and areas of drought to assess whether or not there are discernable global changes in the distribution of moisture availability useful to food and fiber production and management of fresh water resources

Results. NASA did not achieve the indicator. The early analyses focused on calibrating the sensors and validating their accuracy.

Data Quality. The science outcomes accurately reflect performance and achievements in FY 2002.

Data Sources. Performance assessment data is from normal project management reporting and is verified and validated by the program executive or program scientist.

Indicator 4. Establish passive and active rainfall retrievals of zonal means to establish a calibration point for long-term data records of the World Climate Research Program, Global Precipitation Climatology Project (GPCP)

Results. Researchers established a calibration point by comparing TRMM Version 5 satellite data products and GPCP data. This allows us to use TRMM data to calibrate a long-term record of GPCP.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. See indicator 1.

Annual Performance Goal 2Y2. Increase understanding of global ocean circulation and how it varies on interannual, decadal, and longer time scales by meeting two of two performance indicators.

NASA achieved the annual performance goal with a rating of green. The progress made this year in understanding changes in sea ice cover in the Arctic and Antarctic led to an assessment of green. Researchers examined for the first time the perennial ice cover trends and found dramatic changes.

Annual Performance Goal Trends for Earth Science

Annual Performance Goal	Performance Assessment			
	FY 1999	FY 2000	FY 2001	FY 2002
Strategic Goal 1. Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth.				
Objective 1. Discern and describe how the Earth is changing.				
2Y1	●	●	▲↓	▲
2Y2	●	●	●	●
2Y3	▲	●↑	▲↓	●↑
2Y4	▲	●↑	●	▲↓
2Y5	●	●	●	●
2Y6	●	●	●	●
Objective 2. Identify and measure the primary causes of change in the Earth system.				
2Y7	▲	●↑	●	●
2Y8	▲	●↑	●	●
2Y9	●	●	●	●
Objective 3. Determine how the Earth system responds to natural and human-induced changes.				
2Y10	▲	●↑	●	●
2Y11	▲	●↑	▲↓	●↑
2Y12	●	●	●	●
2Y13	▲	●↑	●	●
2Y14	●	●	●	●
2Y15	●	●	●	●
Objective 4. Identify the consequences of change in the Earth system for human civilization.				
2Y16	●	●	●	●
2Y17	▲	●↑	●	●
2Y18	▲	●↑	●	●
Objective 5. Enable the prediction of future changes in the Earth system.				
2Y19	●	●	●	●
2Y20	●	●	●	●
2Y21	▲	●↑	●	●
2Y22	▲	●↑	●	●
Strategic Goal 2. Expand and accelerate the realization of economic and societal benefits from Earth science information and technology.				
Objective 1. Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private-sector decision makers.				
2Y23	●	●	●	●
Objective 2. Stimulate public interest in and understanding of Earth system science and encourage young scholars to consider careers in science and technology.				
2Y24	●	●	●	●
Strategic Goal 3. Develop and adopt advanced technologies to enable mission success and serve national priorities.				
Objective 1. Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation.				
2Y25	●	◆	◆	●↓
Objective 2. Develop advanced information technologies for processing, archiving, accessing, visualizing, and communicating Earth science data.				
2Y26	N/A	N/A	N/A	■
2Y27	N/A	N/A	N/A	■
Objective 3. Partner with other agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction.				
2Y28	N/A	N/A	N/A	●
2Y29	▲	●↑	▲↓	●↑
2Y30	◆	◆	◆	◆
2Y31	●	●	●	●

Indicator 1. Routine (every 10 days) analysis from a data-assimilating global ocean model, using NASA satellite observations, will be used to evaluate ocean circulation changes. (http://www.ecco.ucsd.edu/)

Results. NASA satellites helped establish a new technique to assimilate ocean data. Operational production needs to be established.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The project homepage contains information on the data and links to publications and collaboration information: http://www.ecco.ucsd.edu/.

Indicator 2. Sponsor research and satellite data analysis to develop and publish the trends in the duration and dynamics of the sea ice season for the Arctic and Antarctic polar sea ice covers for the period 1979-1999

Results. NASA-sponsored research to develop and publish trend data showing the Arctic ice cover decreased by several percent per decade from 1979 to 2000, while in the Antarctic, it increased from 1979 to 1998.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Some examples of journals that published information about this indicator include:

Fukumori, I., 2002: A partitioned Kalman filter and smoother, Monthly Weather Review, 130, 1370-1383.

Parkinson, C. L., 2002: Trends in the length of the Southern Ocean sea-ice season, 1979-99, Annals of Glaciology, 34, 435-440.

Annual Performance Goal 2Y3. Increase understanding of global ecosystems change by meeting at least three of four performance indicators.

NASA achieved the annual performance goal with a rating of green. Seasonal and interannual changes in terrestrial and marine primary productivity are key measures of global ecosystem change. In FY 2002, we ensured the continuing utility of estimating global primary productivity for the time series of ocean color and vegetation index data. Merging data from separate instruments increased daily ocean color spatial coverage. In addition, the quantitative comparisons of regional vegetation-index data products appeared in peer-reviewed journals. We took a first step toward improving satellite-derived marine productivity estimates. Field campaigns produced solid validation for many terrestrial ecosystem data products.

Indicator 1. Merge Moderate Resolution Imaging Spectroradiometer (MODIS) instrument and Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data to increase the global ocean color data coverage by 25 percent from a baseline of 17 percent per day

Results. The indicator was achieved. A software program merged the MODIS and SeaWiFS Level-3 products. The application converted the 4.6-kilometer MODIS Level-3 products to the 9-kilometer SeaWiFS format, combined the data by weighted averaging, and produced standard SeaWiFS-like Level-3 products as output. These products can be processed more or displayed using existing software (for example, SeaDAS, or SeaWiFS Data Analysis System).

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The following is an example of a journal that published information about the indicator: Kwiatkowska, E.J. and G.S. Fargion: China, October 23-27, 2002: "Merger of Ocean Color Data from Multiple Satellite Missions within the SIMBIOS Project," The International Society for Optical Engineering's Symposium on Remote Sensing of the Atmosphere, Ocean, Environment, and Space.

Indicator 2. Test our ability to discriminate phytoplankton from other constituents in coastal waters using observations of phytoplankton fluorescence observations acquired by MODIS

Results. Numerous underflights validated the fluorescence line height that MODIS recorded. Once validated, the observations helped differentiate between color dissolved material and phytoplankton pigments in coastal areas.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The following is an example of a journal that published information about the indicator: Validation of Terra-MODIS Phytoplankton Chlorophyll Fluorescence Line Height: 1. Initial Airborne Lidar Results, Frank E. Hoge, Paul E. Lyon, Robert N. Swift, James K. Yungel, Mark R. Abbott and Ricardo M. Letelier. Submitted to Applied Optics in September 2002.

Indicator 3. Release first comprehensive validation of MODIS land data products using results from the South African Fire-Atmospheric Research Initiative (SAFARI 2000) field campaign and related field validation programs

Results. SAFARI 2000 validated MODIS land data products such as Leaf Area Index, fraction of Photosynthetic Active Radiation, fire, and burn scar. Ground-based measurements showed accuracy to within the field measurement uncertainty.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment. A special issue of Remote Sensing of Environment documented the validation material.

Data Sources. Information about the MODIS land data product validation and resulting publications is located at http://modis-land.gsfc.nasa.gov/ and http://modarch.gsfc.nasa.gov/MODIS/LAND/VAL/. Information on special journal issues related to the SAFARI 2000 field campaign is available at http://safari.gecp.virginia.edu/.

The following is an example of a journal that published information about the indicator: Justice, C. O., Giglio, L., Korontzi, S., Owens, J., Morisette, J. T., Roy, D., Descloitres, J., Alleaume, S., Petitcolin, F., and Kaufman, Y. The MODIS fire products, Remote Sensing of Environment, in press.

Indicator 4. Establish a quantitative relationship between vegetation indices time series derived from Advanced Very High-Resolution Radiometer (AVHRR) and MODIS to ensure long-term continuity and comparability of time series

Results. Several studies quantitatively related AVHRR and MODIS vegetation index data and the results were prepared for publication. These studies focused on particular regions and time spans. The SAFARI 2000 and Large-Scale Atmosphere Biosphere Experiment in Amazonia, Ecological Research Program (LBA-ECO) field campaigns compared results from the AVHRR and the Terra-MODIS instruments.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Publications include: Huete, A., Didan, K., Miura, T., and Rodriguez, E., 2002, Overview of the Radiometric and Biophysical Performance of the MODIS Vegetation Indices. Remote Sensing of Environment. (Special issue in press).

Annual Performance Goal 2Y4. Increase understanding of stratospheric ozone changes, as the abundance of ozone-destroying chemicals decreases and new substitutes increases by meeting two of two performance indicators.

The overall assessment for this annual performance goal is yellow. NASA provided a total ozone data set of continuous trends. A new merged data record from the Total Ozone Mapping Spectrometer (TOMS) series of instruments and Solar Backscatter Ultraviolet (SBUV/2) instruments was assembled. This record will be updated using data from more recent SBUV/2 instruments. Collaborative work between United States and European scientists will add other instrument data to this record. The instruments for ozone profile trends above 20 kilometers are aging and data from recently launched satellite instruments will not be sufficiently mature to address ozone recovery for several years. Below 20 kilometers, space-based data are presently more limited and, while NASA launched new instruments, it will take many years to develop a useful long-term record.

Indicator 1. Provide continuity of calibrated data sets for determining long term trends in the total column and profile abundances of stratospheric ozone with sufficient precision to enable the later assessment of expected ozone recover

Results. We provided data continuity despite the failure of QuikTOMS and calibration problems with Earth Probe/TOMS. The National Oceanic and Atmospheric Administration's NOAA 16 and NOAA 17 SBUV/2 instruments should last for several years. NOAA planned to continue these measurements until the National Polar-orbiting Operational Environmental Satellite System becomes operational. A merged record containing 23 years of data, from 1979 to 2001 is available on the Web. It will be updated using NOAA 16 and NOAA 17 data.

For the Upper Stratospheric Profile (from about 20 to 50 kilometers), the Stratospheric Aerosol and Gas Experiment (SAGE) and HALogen Occultation Experiment (HALOE) instruments provided a self-calibration mechanism that makes their records invaluable for the long-term trends. While some questions existed about the calibration of SBUV instruments in the past, recent instruments performed far better. SBUV record can be checked using data from SAGE.

In the Lower Stratosphere (tropopause to about 20 kilometers), given very high variability of ozone in the lower stratosphere and the difficulty of isolating different mechanisms of change using sparse data, chances of developing a good understanding of the trends in this region in the next 5 years are not very promising. The Aura and ENVIronmental SATellite instruments should provide better coverage of the lower stratosphere, but it will take years to develop a useful long-term record.

Data Quality. Data on total column ozone and profile ozone trends played prominent roles in the latest international ozone assessment, (Scientific Assessment of Ozone Depletion: 2002, World Meteorological Organization, Global Ozone Research and Monitoring Project Report (in press).

Data Sources. Information on the project and related publications is located at http://code916.gsfc.nasa.gov/Data_services/merged. Upper Stratospheric Profile satellite data, including SAGE, HALOE, SBUV, Umkehr, and the Network for the Detection of Stratospheric Change lidars, is available at http://www.ndsc.ws.

Indicator 2. Characterize the inter-annual variability and possible long-term evolution of stratospheric aerosol characteristics and profile abundances to assist in the

interpretation of observed ozone changes and chemistry-climate interactions. This requires a combination of consistently processed data records from ground-based, airborne, balloon-borne, and space-based measurements

Results. NASA achieved the indicator. NASA supported the World Climate Research Programme's Stratospheric Process and the Role in Climate Assessment of Stratospheric Aerosol Properties. The assessment considered NASA's SAGE II and HALOE results, as well as data from ground-based lidar and in situ measurement systems. A new version of SAGE II data released in late 2001 produced improved short wavelength aerosol extinction information near the tropopause. The data helped us understand the observed seasonal variations in lower stratospheric aerosol. SAGE III provided multi-wavelength aerosol extinction data. The improved wavelength sampling (9 wavelengths from 385 to 1,550 nanometers) should increase our understanding of aerosol microphysical changes.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The following is an example of a journal that published information about the indicator: Thomason, L. W., Andreas B. Herber Takashi Yamanouchi, Kaoru Sato, Sharon P. Burton: Arctic Study on Tropospheric Aerosol and Radiation: Comparison of tropospheric aerosol extinction profiles measured by airborne photometer and SAGE II, submitted to Geophysical Research Letters, October 2002.

Annual Performance Goal 2Y5. Increase understanding of change occurring in the mass of the Earth's ice cover by meeting at least three of four performance indicators.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results segment of Part I.

Annual Performance Goal 2Y6. Increase understanding of the motions of the Earth, the Earth's interior, and what information can be inferred about the Earth's internal processes by meeting at least three of four performance indicators.

NASA achieved the annual performance goal with a rating of green. The Oersted and CHAllenging Mini-Satellite Payload (Danish and German, respectively) operations improved the measuring and modeling of the geomagnetic field. NASA supported these efforts with launch support, instruments, and scientific analysis. NASA demonstrated a factor-of-100 improvement in the positioning accuracy of the Global Positioning System (GPS) on a real-time global basis. The achievement will have a significant effect on satellite airborne science capabilities, as well as aircraft safety, marine operations, mining, construction, and agriculture. In addition, NASA launched Gravity Recovery and Climate Experiment (GRACE), which offers a new paradigm in gravity field applications. Its ability to track water mass within the Earth system will significantly advance the ability to assess flood risk, climate change, and water resources. NASA altered the Continuous Observations of the Rotation of the Earth (CORE) Program—designed to enhance Very Long Baseline Interferometry (VLBI) observing capability—to increase reference frame accuracy to the millimeter level, and provide a more accurate measure of changes in Earth rotation to help us understand changes in water storage on a global basis.

Indicator 1. Produce first estimate of the secular (long-term) change of the Earth's magnetic field from continuous satellite measurements of the geomagnetic field. Estimate the long-term variation to 3 nano Tesla peryear or better which is equivalent to a change of 1 part in 20,000

Results. NASA achieved the indicator by developing a comprehensive geomagnetic modeling technique that incorporated main, crustal, and external field terms to model long-term geomagnetic secular variation. This approach will become the standard for future modeling efforts because it better estimates the sources of the geomagnetic field. The 5-year averages for the first six gauss coefficient terms are no larger than 3 nano Tesla per year.

A second publication this year derived the secular variation from two sets of measurements acquired by Magsat—a NASA geomagnetic satellite and the Oersted Satellite—a NASA/Danish/French collaboration. The secular variation error for the 20-year timespan is better than 3 nano Tesla per year.

Data Quality. The data quality is high, as these are world-class, first-ever observations published in prestigious, peer-reviewed publications.

Data Sources. The paper commanded a cover photo for Nature and inclusion in the prestigious peer-reviewed journal Royal Academy of Science.

Other sources include:

Sabaka, T.N. Olsen, R.A. Langel, A Comprehensive Model of the quiet-time, near-Earth magnetic field: phase 3, Geophysical Journal International, 151, 32-68, 2002.

Hulot, G.C., C. Eymin, B. Langlais, M. Mandea, N. Olsen, 2002: Small Scale structure of the geodynamo inferred from Orsted and Magsat satellite data, Nature, 416, 620-523.

Indicator 2. Complete the evaluation of the CORE concept to demonstrate a nearly 300-percent improvement in Earth rotation precision using the new Mark IV correlator technology and an international consortium of VLBI observatories

Results. The evaluation showed that a 300-percent improvement in Earth-rotation precision was not

possible. A blue ribbon panel report by members of the international space geodetic community recommended integrating GPS and VLBI observations to achieve an increase in temporal resolution and improve the accuracy of measurement. Many of the panel report recommendations became part of the program. A National Geodetic Observatory program seeks to better integrate the three NASA geodetic observing networks into a more effective and accurate capability.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The review process and the draft report are available at http://ivscc.gsfc.nasa.gov/core-panel/.

Indicator 3. Complete Solar Laser Ranging 2000 (SLR2000) prototype development and begin evaluation of the performance of new SLR2000 automated satellite ranging station

Results. The SLR2000 prototype was successfully completed; performance testing will run through FY 2003.

Data Quality. Peer review is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. More than 100 members of the International Laser Ranging Service had the opportunity to inspect the prototype SLR2000 instrument.

Indicator 4. Evaluate the ability of the real-time precision GPS positioning software to produce better than 40-centimeter global real-time positioning using NASA's Global GPS Network

Results. NASA exceeded this indicator. The GPS software produced 10-centimeter global real-time positioning—a factor of four beyond the goal. The capability is being tested on airplanes.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Data, project information, and publications are located at http://gipsy.jpl.nasa.gov/igdg/.

Indicator 5. Complete preliminary algorithms for mass flux estimation from temporal gravity field observations in preparation for the GRACE mission

Results. GRACE had a successful launch and the science team was selected. Preliminary algorithms and gravity fields were generated.

Data Quality. Some of the data and algorithms appeared in peer-reviewed journals.

Data Sources. More than 50 proposals responded to the GRACE and Gravity component announcement. The proposals offered ways to apply algorithms to the GRACE data set. The GRACE Web site provides additional insight into the modeling algorithms and the status of GRACE data processing at http://www.csr.utexas.edu/grace/. Examples of works in print, in press, and submitted are

Jayne, S.R. J.M. Wahr, and F.O. Bryan Observing ocean heat content using satellite gravity and altimetry, Journal of Geophysical Research, submitted.

Swenson, S. and J. Wahr, Estimated effects of the vertical structure of atmospheric mass on the time-variable geoid, Geophysical Research Letters (in press).

Strategic Objective 2. Identify and measure the primary causes of change in the Earth system

Annual Performance Goal 2Y7. Increase understanding of trends in atmospheric constituents and solar radiation and the role they play in driving global climate by meeting at least three of four performance indicators.

NASA achieved the annual performance goal with a rating of green. Our continuous sampling of tropospheric air showed a decrease in halocarbons and an increase in replacement chemicals. A NASA-sponsored flask-sampling program also showed similar behavior. Comparisons between the NASA and NOAA networks reduced uncertainties in the trend results. Combined measurement of carbon monoxide and methane in a new model will improve future investigations of interannual variations in global emissions. NASA created integrated data sets to study aerosols using multiple satellites and ground-based programs. The changes allowed us to identify aerosol sources and to detect and quantify sulfate aerosols from industrial pollution.

Indicator 1. Provide continuity of 22 years of concentration measurements (and associated standards development) of anthropogenic and naturally occurring halogen-containing chemicals and other chemically active greenhouse gases to provide for an understanding of future changes in ozone and climate forcing

Results. NASA achieved the indicator. The NASA Advanced Global Atmospheric Gases Experiment (AGAGE) Network's measurement activities continued with a high level of success, and standards comparisons with the Climate Monitoring and Diagnostics Laboratory Network reduced earlier differences in the results from these two data archives. Data from the AGAGE and the NASA-funded University of California, Irvine flask sampling network played important roles in the 2002 World Meteorological Organization/United Nations Environment Programme (WMO/UNEP) Scientific Assessment of Ozone Depletion.

Data Quality. Data on atmospheric halocarbon abundances played prominent roles in the latest international ozone assessment, "Scientific Assessment of Ozone Depletion: 2002," World Meteorological Organization, Global Ozone Research and Monitoring Project Report

(in press). Publications from the AGAGE and UCI programs appeared in peer-reviewed scientific literature such as the Journal of Geophysical Research.

Data Sources. The Carbon Dioxide Information and Analysis Center archived the AGAGE Network data. The World Data Center for Atmospheric Trace Gases archived the University of California, Irvine Network data. Both centers are located at the U.S. Department of Energy, Oak Ridge National Laboratory.

Indicator 2. Use data assimilation techniques to combine carbon monoxide and methane measurements from Measurements of Pollution in the Troposphere (MOPITT) with chemical transport models of the atmosphere to help characterize interannual differences in global emissions

Results. NASA achieved the indicator. A prototype for deriving surface fluxes of carbon monoxide using MOPITT data and the Model for OZone And Related chemical Tracers-2 (MOZART-2) is in the testing phase. In addition, a university group is assimilating the data to support the TRAnsport and Chemical Evolution over the Pacific (TRACE-P) field program, investigating outflow of pollutants from Asia. Better agreement of retrieved data with co-located in-situ profiles led to improved accuracy and coverage.

The loss of some MOPITT data in 2001 required the development of a new retrieval scheme. A much-improved algorithm is in the testing phase. The new data appeared to retain almost the same quality as the pre-anomaly data. In regions of high signal-to-noise ratio, such as over bright desert areas, credible results are now possible. Work is continuing to extend these results.

Data Quality. The project homepage includes links to papers at International Society for Optical Engineering (SPIE's) 44th Annual Meeting. These peer-reviewed publications are the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The homepage of the University of Toronto MOPITT team provided useful information including a list of relevant papers: http://www.atmosp.physics.utoronto.ca/MOPITT/ home.html.

Indicator 3. Provide first comprehensive multi-instrument/multi-angle integrated data set for study of sources/sinks and distribution of tropospheric aerosols over land based on data from Total Ozone Mapping Spectrometer, MODIS, and Multi-angle Imaging Spectroradiometer (MISR) instruments

Results. The combined satellite data set helped identify aerosol sources. MODIS and SeaWiFS satellite data augmented the long-term record of smoke from 1979 to the present, started by TOMS. The combined data sets detected dust over all surfaces, helping researchers determine the basic optical properties (particle size, refractive index, and absorption coefficients). The combined sets formed a fairly complete picture of aerosol properties. For example, the combined data from TOMS, SeaWiFS, and Clouds and the Earth's Radiant Energy System (CERES) quantified how smoke aerosols change the cloud forcing in the Southeast Asia region.

Data Quality. Peer-reviewed publications represent a high level of quality in the scientific community.

Data Sources. The project homepages for the data collecting instruments provide data, news, collaborators, and publications. The TOMS homepage is http://skye.gsfc.nasa.gov/. The homepage for MODIS is located at http://modis.gsfc.nasa.gov/ and the one for MISR is at http://www-misr.jpl.nasa.gov/.

Indicator 4. Reduce the uncertainty in the retrievals of upper troposphere/lower stratosphere water vapor (from microwave soundings) by 10 to 30 percent through improved laboratory spectroscopic measurements of the water vapor continuum

Results. The new laboratory system displayed the required sensitivity, simultaneous measurement capability, and measurement accuracy.

Data Quality. Peer-reviewed publications represent a high level of quality in the scientific community—see below for references.

Data Sources. NASA sponsored an international workshop on "Spectroscopic Needs for Atmospheric Sampling" that highlighted the findings of the laboratory studies. Peer-reviewed literature such as the Journal of Molecular Spectroscopy published the findings.

Annual Performance Goal 2Y8. Increase understanding about the changes in global land cover and land use and their causes by meeting at least two of three performance indicators.

NASA achieved the annual performance goal with a rating of green. Case studies of the NASA Land Cover Land Use Change Program are included in a book under development. Several chapters will discuss changes associated with natural fires and deforestation. Second, a 15-year history of fire occurrences and emissions over North America based on operational satellite data is being prepared. The results on quantification of the effect of deforestation in the Amazon on global carbon balance were under consideration for publication.

Indicator 1. Publish the first set of regional land cover and land use change case studies and a synthesis of their results

Results. Published research on the project entitled Landscape Dynamics and Land Use Land Cover Change in the Great Basin-Mojave Desert showed the importance of environmental changes in semiarid regions, their drivers, and the implications for future climatic, land use, and land cover scenarios.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Some examples of journals that published information about this indicator include: Elmore, A. J., J. F. Mustard, and S. J. Manning, Regional patterns of great basin community response to changes in water resources: Owens Valley, CA, (in press) Ecological Applications 2002.

House, J., S. Archer, D. Breshears, RJ Scholes. 2002. Conundrums in mixed woody-herbaceous plant systems. The Journal of Biogeography received the paper submission.

Indicator 2. Characterize the role of land cover changes associated with natural fires in determining the carbon balance of ecosystems in at least two major regions of the boreal forests, quantify their impact on the global carbon budget, and submit the results for publication

Results. Two major projects and publication in several respected journals helped achieve this indicator. The first project, Modeling and Monitoring Effects of Area Burned and Fire Severity on Carbon Cycling, Emissions, and Forest Health and Sustainability in Central Siberia, involved a United States-Russian team that developed a comprehensive data set on fire emissions, behavior, and ecosystem effects in the boreal zone. In the second, Development of Long Term Inventory of Fire Burned Areas and Emissions of North America's Boreal and Temperate Forests, data from the early period of the AVHRR record were analyzed.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Some examples of journals that published information about this indicator include: Conard, Susan G., Anatoly I. Sukhinin, Donald R. Cahoon, Eduard P. Davidenko, Brian J. Stocks, and Galina A. Ivanova. Determining effects of area burned and fire severity on carbon cycling and emissions in Siberia. Climatic Change (in press).

Csiszar, I., A. Abdelgadir, Z. Li, J. Jin, R. Fraser and W.M. Hao, Interannual changes of active fire detectability in North America from long-term records of the Advanced Very High Resolution Radiometer. Journal of Geophysical Research, accepted.

Indicator 3. Characterize the role of deforestation in the carbon balance of ecosystems of the Amazonian tropical forest, quantify the impact on the global carbon budget, and submit the results for publication

Results. The LBA-ECO Research Program and the Interdisciplinary Program contributed to achieving this indicator. LBA-ECO entered its second phase, and most Land Cover Land Use Change (LCLUC) projects were renewed. In FY 2002, the team—named the present and future effects of ground fires on forest carbon stocks, metabolism, hydrology and economic value in Amazonia and the Cerrado—continued working with large experimental forest fires, manipulating fire frequency and seed sources in four pairs of 1-hectare forest plots in the Tapajós forest. On the project, Anthropogenic Landscape Changes and the Dynamics of Amazon Forest Biomass, researchers assessed the effects of intensive land uses—such as habitat fragmentation, forest regeneration, selective logging, and fire—on biomass and carbon storage in Amazonian forests. Multiple journals published both sets of findings.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Publications include:

Potter, C., E. Davidson, D. Nepstad, C. Carvalho. Ecosystem modeling and dynamic effects of deforestation on trace gas fluxes in Amazon tropical forests. Forest and Ecology Management. 5350: 1-21.

Laurance, W. F., M. A. Cochrane, S. Bergen, P. M. Fearnside, P. Delamonica, C. Barber, S. D'Angelo, and T. Fernandes. 2001. The future of the Brazilian Amazon. Science. 291: 438-439.

Annual Performance Goal 2Y9. Increase understanding of the Earth's surface and how it is transformed and how such information can be used to predict future changes by meeting at least four of five performance indicators.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results segment of Part I.

Strategic Objective 3. Determine how the Earth system responds to natural and human-induced changes

Annual Performance Goal 2Y10. Increase understanding of the effects of clouds and surface hydrologic processes on climate change by meeting at least four of five performance indicators.

NASA achieved the annual performance goal with a rating of green. Multiangle Imaging SpectroRadiometer aerosol products helped assess global aerosol budgets and calculate aerosol radiative forcing. The products also served to retrieve surface bidirectional reflectance and albedo. Their quality and accuracy improved cloud identification and screening over both land and ocean. Finally, a revised set of aerosol mixtures in the retrieval algorithm produced tighter constraints on aerosol type with little loss of spatial coverage.

Indicator 1. Continue assembling and processing of satellite data needed for the multi-decadal global cloud

Climatology being developed under the International Satellite Cloud Climatology Project (ISCCP). Reduce uncertainty (3-7 percent in monthly mean) in the current ISCCP dataset of globally observed cloud characteristics, particularly in the polar regions, by comparing it with new satellite datasets that provide new constraints on the derived quantities and with in situ ground-based and airborne measurements

Results. Calculation of top-of-atmosphere shortwave and longwave radiative fluxes using the ISCCP cloud products showed excellent quantitative agreement with the long-term Earth Radiation Budget Experiment flux anomalies at low latitudes associated with several El Niño Southern Oscillation (ENSO) events and the Mount Pinatubo volcanic eruption as well as the long-term change between the 1980s and 1990s. This result showed that much of these flux anomalies occurred because of cloud changes determined by ISCCP. The finding also confirmed the accuracy of the ISCCP radiance calibration standard for all of the weather satellites (the only one in existence). Climate models predict a change in the intensity distribution of mid-latitude storms in a warming climate: the ISCCP cyclone cloud survey provides an evaluation of the resulting radiation budget perturbations that would be associated with such a change (one component of cloud-radiative feedbacks).

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Information on the Earth Observing System (EOS)-related instruments and publications are located at http://eospso.gsfc.nasa.gov/.

Indicator 2. Initiate development of the Cirrus Regional Study of Tropical Anvils and Layers (CRYSTAL) field study to determine the upper tropospheric distribution of ice particles and water vapor and associated radiation fluxes on storms and cloud systems, and on cloud generation, regeneration and dissipation mechanisms and their representation in both regional-scale and global climate models

Results. The Mission was planned and executed successfully in July 2002. It was centered in Key West, FL.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Same as indicator 1.

Indicator 3. Improve the determinations of radiation forcings and feedbacks, and thereby increase accuracy in our knowledge of heating and cooling of the Earth's surface and atmosphere. Continue the analysis of global measurements of the radiative properties of clouds and aerosol particles being made by MISR and CERES instruments on the Terra and Aqua spacecraft

Results. A direct quantitative evaluation of the effects of the diurnal, synoptic, seasonal, and interannual variations of clouds on the radiative part of the diabatic forcing for the atmospheric general circulation, albeit at low vertical resolution, is now possible for the first time. This represented a key step toward evaluating cloud-radiative feedbacks.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. See indicator 1.

Indicator 4. Demonstrate over a variety of landscapes the capability to measure and diagnose soil moisture from airborne platforms, in preparation for a space-flight trial of soil moisture remote sensing

Results. Preliminary results using different types of vegetation in Iowa proved encouraging.

Data Quality. Data from previous field experiments appeared in many scientific publications. Once validated, the data are available to the public through NASA's Distributed Active Archive Center (DAAC). Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Information is available at http://_hydrolab.arsusda.gov/smex02/. In addition, see the data sources for indicator 1.

Indicator 5. Improve the understanding and modeling of the aerosol radiative forcing of climate and its anthropogenic component (reduce current uncertainties of 0.1 to 0.05 in the aerosol column optical thickness and 1 to 0.4 in the Angstrom coefficient). Develop and validate aerosol retrieval and cloud screening algorithms, and processing of satellite data and transport model evaluations for a 20-year Climatology of aerosol optical thickness and particle size

Results. The global monthly mean optical thickness and Angstrom exponent showed no significant trends and oscillate around the average values 0.14 and 0.75, respectively. The optical thickness maxima and minima for the Southern Hemisphere occur around January to February and June to July, respectively. The Northern Hemisphere exhibits a similar pattern, but with maxima in the February to April timeframe. The Northern Hemisphere mean systematically exceeded that average over that of the Southern Hemisphere. The results of AVHRR retrievals during the period affected by the Mount Pinatubo eruption are consistent with the SAGE retrievals of the stratospheric aerosol optical thickness. Time series of the aerosol properties computed for four specific geographic regions showed varying degrees of seasonal variability controlled by local meteorological events and/or anthropogenic activities.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. See indicator 1.

Annual Performance Goal 2Y11. Increase understanding of how ecosystems respond to and affect global environmental change and affect the global carbon cycle by meeting at least four of five performance indicators.

NASA achieved the annual performance goal with a rating of green. Scientifically validated EOS Terra-MODIS higher level data products that became available in FY 2002, the continuing time-series of SeaWiFS ocean color data, and results from field campaigns advanced our understanding of ecosystem responses and global carbon cycling. In particular, NASA demonstrated the ability to identify, quantify, and monitor the duration of major productivity bursts (that is, blooms) for important functional groups of marine algae in the world's oceans. Chlorophyll data products derived from satellite data improved model estimates of carbon export to the deep sea. Improved ecosystem models integrated data acquired from NASA field campaigns. Peer-reviewed journals published results from modeling exercises involving several advanced, multi-factor ecosystem models. The published papers described improvements in the portrayal of land cover and in quantifying the role of land use in ecosystem change. The next modeling steps will require more fully interactive treatment of the important factors controlling ecosystem response.

Indicator 1. Demonstrate the feasibility of using remote sensing imagery to identify functional groups of phytoplankton in the ocean

Results. Using both the spectral signature and intensity of the upwelled radiance as measured by SeaWiFS and MODIS, researchers identified and quantified several functional groups of phytoplankton. They then mapped the distribution and concentration of the calcium carbonate forming coccolithophores and the nitrogen fixing Trichodesmium organisms, which play a key role in the export of carbon to the deep ocean.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The following is an example of a journal that published information about the indicator: Iglesias-Rodríguez, M.D., C.W. Brown, S.C. Doney, J. Kleypas, D. Kolber, Z. Kolber, P.K. Hayes, and P.G. Falkowski. (In press) Representing key phytoplankton functional groups in ocean carbon cycle models: Coccolithophorids. Global Biogeochemical Cycles.

Indicator 2. Develop a relationship between oceanic primary productivity and export of carbon to the deep-sea based on remote sensing observations and ocean biology models

Results. Satellite ocean color data provided the basis for developing empirical models of carbon production and exportation. The scientific community has not reached a consensus on any one model.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Examples of publications include: Gregg, W.W., 2002: Tracking the SeaWiFS record with a coupled physical/biogeochemical/radiative model of the global oceans. Deep-Sea Research, II, 49: 81-105.

Shipe, R.F., U. Passow, M.A. Brzezinski, D.A. Siegel and A.L. Alldredge, 2002: Effects of the 1997-98 El Niño on seasonal variations in suspended and sinking particles in the Santa Barbara Basin. Progress in Oceanography, 54, 105-127.

Indicator 3. Conduct airborne remote sensing campaign in Amazonia to evaluate measurement approaches for vegetation recovery and biomass change following forest clearing and impact of this secondary growth on removal of water from the atmosphere

Results. NASA did not achieve the indicator. After delays in planning and development, NASA agreed to the Brazilian government's request for a new agreement for deployment of United States aircraft to Brazil with a 1-year delay in the airborne campaign. Research on trace gases (primarily carbon dioxide) and wetlands using Brazilian aircraft continued under a separate agreement, but this research did not address the structural changes called for by this indicator. It does address, in part, the issue of secondary growth effects on removal of carbon from the atmosphere. (NOTE: The indicator from the FY 2002 Revised Final Annual Performance Plan incorrectly reads "water." It should read "carbon.")

Data Quality. The International Journal of Remote Sensing published quality information on the airborne videography data. Information on the atmospheric carbon dioxide concentrations had not yet been published, but the data are being analyzed by a world-class laboratory (NOAA CMCL) using established international standards.

Data Sources. Publications include: Hess LL, Novo EMLM, Slaymaker D.M., Holt J., Steffen C., Valeriano D.M., Mertes, LAK, Krug T., Melack J.M., Gastil M., Holmes C., Hayward C. (2002) Geocoded digital videography for validation of land cover mapping in the Amazon basin. International Journal of Remote Sensing 23.

For more information, see http://lba-ecology.gsfc.nasa.gov/ and http://lba.cptec.inpe.br/lba/eng/scientific.htm.

Indicator 4. Assemble and publish the first comprehensive regional analysis of the linkages between land-atmosphere interaction processes and the relationship between trace gas and aerosol emissions and the conse-

quences of their deposition to the functioning of the ecosystems of southern Africa

Results. Two major journals (Journal of Geophysical Research and Global Change Biology) published special issues in FY 2002 on the regional analysis in southern Africa. The SAFARI-2000 field campaign acquired field, airborne, and EOS Terra satellite observations to study land-atmosphere interactions associated with regional biomass burning and industrial emissions in southern Africa. Analyses of data from this field campaign yielded results summarizing both physical and chemical land-atmosphere interactions and linkages between them. In particular, journals published studies quantifying the properties of aerosols (size, shape, and forcing) resulting from biomass burning and their effects on the regional radiation balance. Papers in the Global Change Biology special issue addressed consequences with respect to the ecosystem functioning in the region.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Information on special journal issues related to the SAFARI 2000 Field Campaign is located at http://safari.gecp.virginia.edu/. Other papers of note include:

Dubovik, O., Holben, B., Eck, T., Smirnov, A., Kaufman, Y., King, M., Tanre, D., and Slutsker, I. Variability of Absorption and Optical Properties of Key Aerosol Types Observed in Worldwide Locations. Journal of Atmospheric Sciences 59: 590-608.

Hély, C., S. Alleaume, R.J. Swap, H.H. Shugart, and C.O. Justice, SAFARI-2000 characterization of fuels, fire behavior, combustion completeness, and emissions from experimental burns in infertile grass savannas in western Zambia, Journal of Arid Environment, in press.

Indicator 5. Conduct diagnostic analysis of results from new carbon cycling models that improve the treatment of land use and land management and incorporate the effects of nutrient deposition as well as climate change, carbon dioxide enrichment, and land cover change to assess interrelation among these multiple factors affecting these ecosystems

Results. Multiple journals published results from modeling exercises involving several advanced, multi-factor ecosystem models. Some of these papers described improvements in the portrayal of land cover and in quantifying the role of land use in ecosystem change. Others showed that more than one factor can account for known ecosystem responses and that the model needed to more fully integrate multiple interactions among controlling factors.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Publications include: Li, C., X. Wang, M. Cao, P. Crill, Z. Dai, S. Frolking, B. Moore, W. Salas, W. Song, and X. Wang. 2001: Comparing a process-based agro-ecosystem model to the IPCC methodology for developing a national inventory of N_2O emissions from arable lands in China. Nutrient Cycling Agroecosystems 60: 159-175.

McGuire, A., S. Sitch, J. Clein, R. Dargaville, G. Esser, J. Foley, M. Heimann, F. Joos, J. Kaplan, D. Kicklighter, R. Meier, J. Melillo, B. Moore III, I. Prentice, N. Ramankutty, T. Reichenau, A. Schloss, H. Tian, L. Williams, and U. Wittenberg. 2001: Carbon balance of the terrestrial biosphere in the twentieth century: Analyses of CO_2, climate and land use effects with four process-based ecosystem models. Global Biogeochemical Cycles, 15: 183-206.

Annual Performance Goal 2Y12. Increase understanding of how climate variations induce changes in the global ocean circulation by meeting at least four of six performance indicators.

NASA achieved the annual performance goal with a rating of green. Researchers linked high-resolution deformation, volume, and transport characteristics of Arctic Sea ice to dominant atmospheric circulation patterns, suggesting that atmospheric changes can strongly influence ice formation and ocean circulation. In addition, progress was made in advancing strategies of assimilation of satellite-derived sea ice data into process and climate models, which will enhance understanding of the ice-climate linkages.

Indicator 1. Diagnostic analysis of seasonal and interannual variability induced in the interior ocean based on forcing of an ocean model with three years of high resolution ocean winds (Ocean Surface Vector Winds Science Team)

Results. Scientists achieved the indicator, completing the first-ever collection of 3 years of high-resolution ocean vector wind data from August 1999 to July 2002. The findings are located at http://www.seawinds.jpl.nasa.gov. For the first time, scientists recorded an annual cycle of global distributions of high-resolution ocean vector winds.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Examples of publications include: Freilich, M. H., and B. A. Vanhoff, in press. The accuracy of remotely sensed surface wind speed measurements, Journal of Atmospheric and Oceanic Technology.

Milliff, R. F., M. H. Freilich, W. T. Liu, R. Atlas, and W. G. Large, 2001. Global ocean surface vector wind observations from space, Observing the Oceans in the 21st Century, edited by C. J. Koblinsky and N. R. Smith, Bureau of Meteorology, Melbourne, Australia, 102-119.

Indicator 2. Near decade-long sea surface topography time series will be assimilated into high resolution Pacific Ocean model to elucidate the mechanisms of the Pacific Decadal Oscillation and its impact on seasonal/decadal climate variations

Results. Low-resolution model computations showed Indonesian through flow regulates the exchange of waters between the tropical and middle latitudes, and thereby, could alter the time interval between El Niño and La Niña. Another study described the origin and pathway of El Niño waters.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Lee, T., I. Fukumori, D. Menemenlis, Z. Xing, and L.-L. Fu, 2002. Effects of the Indonesian throughflow on the Pacific and Indian Oceans, Journal of Physical Oceanography, 32, 1404-1429.

Fukumori, I., T. Lee, B. Cheng, and D. Menemenlis, submitted. The origin, pathway, and destination of Niño3 water estimated by a simulated passive tracer and its adjoint, Journal of Physical Oceanography.

Indicator 3. From Ocean Topography Experiment (TOPEX) time series, in situ observations of the World Ocean Data Assimilation Experiment, and assimilation of these data into ocean models, ascertain whether detectable changes in the deep ocean have occurred over the last decade

Results. Data assimilating model computations of four-dimensional ocean circulation were made. Torque produced by deep ocean circulation showed influence over the Chandler wobble and the Earth's shape.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The following is an example of a journal that published information about the indicator: Dickey, J.O., S. L. Marcus, O. de Viron, and I. Fukumori, in press. Recent changes in Earth oblateness, Science.

Indicator 4. Submit for publication the first estimate of the inter-annual variability of Arctic Ocean seasonal ice production and heat and brine flux, from three years of Canadian Radar Satellite (RADARSAT) observations

Results. The published results showed, for the first time, the contrast in Arctic Ocean sea ice deformation and seasonal ice volume production between 1996 and 1998. Researchers found the 1997-1998 ice deformation created an ice volume 1.6 times that of the first year.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Publications include: Kwok, R., Arctic, 2002: Ocean sea ice area and volume production: A contrast of two years—1996/97 and 1997/98. Annals of Glaciology, 34, 447-453.

Kwok, R. and G. F. Cunningham. Seasonal ice area and volume production of the Arctic Ocean: November 1996 through April 1997. Journal of Geophysical Research—Oceans (in press).

Indicator 5. Complete a preliminary review of how data assimilation techniques are currently being used to improve knowledge of the polar oceans (in particular the Arctic), through convening a workshop. Provide recommendations that outline the way forward for future application of data assimilation techniques for polar oceans research in NASA's Earth Science Enterprise

Results. The participants shared and discussed data assimilation methods. The participants provided a comprehensive set of recommendations was provided, in specific areas in which NASA can improve models of sea ice processes. These included: (1) articulation of how sea ice data assimilation can help address the science questions, (2) scientific community outreach, (3) suggested improvements to implementation of data assimilation methods, (4) use of satellite data in forcing, facilitating assimilation and evaluation through access to computational resources, and (5) evaluation considerations.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. For more information on this project and the report, see http://oceans.nasa.gov/csp/index3.html, with planned submission to Bulletin of the American Meteorological Society or a similar publication.

Indicator 6. Submit for publication twenty years of Fram Strait sea ice flux from RADARSAT and passive microwave ice motion. Sea ice flux through the Fram Strait represents export of fresh water from the Arctic Ocean, which in turn influences deep ocean circulation and climate variations

Results. The submitted papers described how sea level pressure gradient dominated the flow through Fram Strait, but showed less correlation in years of negative North Atlantic Oscillation because of the decreased dominance of the large-scale atmospheric pattern on sea level pressure. The North Atlantic Oscillation index explains more than 70 percent of the ice area flux through the Fram Strait. Over the 17-year period, an average of about 7 percent of the ice area and 10 percent of the ice volume went through this passage.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The following is an example of a journal that published information about the indicator: Kwok, R., 2000: Recent changes of the Arctic Ocean sea ice motion associated with the North Atlantic Oscillation, Geophysical Research Letters, 27(6), 775-778.

Rothrock, D. A., R. Kwok, and D. Groves, 2000: Satellite Views of the Arctic Ocean Freshwater Balance, The Freshwater Budget of the Arctic Ocean, edited by E. Lyn Lewis, Kluwer Academic, 409-452.

Annual Performance Goal 2Y13. Increase understanding of stratospheric trace constituents and how they respond to change in climate and atmospheric composition by meeting two of two performance indicators.

NASA achieved the annual performance goal with a rating of green. The SAGE III Ozone Loss and Validation Experiment (SOLVE) examined the processes controlling ozone levels at mid- to high latitudes, thereby enabling the improved prediction of ozone variability in an evolving future atmosphere. The joint endeavor between SOLVE and the Euro-SOLVE component of the European Communities-sponsored Third European Stratospheric Experiment on Ozone 2000 campaign was the most comprehensive international field measurement campaign ever conducted to examine the frailties of the Earth's stratospheric ozone layer. The unprecedented measurement and analysis suite yielded important information with which to project the future of ozone chemistry and transport in an atmosphere with increased abundances of greenhouse gases. This information is essential in developing an understanding of the nature and timing of the expected long-term recovery of the ozone layer as the abundances of ozone-destroying chemicals decrease in the atmosphere because of international agreements.

In addition, our understanding of the variability of temperatures, ozone concentrations, and water vapor in and above the tropopause region has greatly improved over the past year, and we expect significant progress on this problem to continue for the next few years.

Indicator 1. Assess the possible impact of the increased abundances of greenhouse gases on the future evolution of Northern Hemisphere high latitude ozone concentration. Based on data from the SOLVE experiment

Results. SOLVE data played an important role assessing these impacts and in the polar ozone chapter of the 2002 WMO/UNEP Scientific Assessment of Ozone Depletion. These data also factored heavily in discussions at a March 2002 international workshop on Arctic ozone loss. The Journal of Geophysical Research published a special issue of dedicated to the SOLVE results. The SOLVE results factor heavily into the planning and implementation of SOLVE–2, which will occur in FY 2003 and be heavily dedicated to SAGE III validation.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. SOLVE played a prominent role in the latest international ozone assessment, (Scientific Assessment of Ozone Depletion: 2002), World Meteorological Organization, Global Ozone Research and Monitoring Project Report (in press). Publications from both the SOLVE and the Third European Stratospheric Experiment on Ozone 2000 campaigns appeared in the Journal of Geophysical Research.

Indicator 2. Document and submit for publication the respective variability of temperatures, ozone concentrations, and water vapor in and above the tropopause region and assess the interconnectedness of these changes through retrospective modeling and data analysis

Results. Two separate documented theories, convective dehydration and slow ascent, appeared in publications.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Some examples of journals that published information about this indicator include: Dessler, A.E., The effect of deep, tropical convection on the tropical tropopause layer, Journal of Geophysical Research, 10.1029/2001JD000511, 2002.

Holton, J.R., and A. Gettelman, 2000: Horizontal transport and the dehydration of the stratosphere, Geophysical Research Letters, 28, 2799-2802.

Annual Performance Goal 2Y14. Increase understanding of global sea level and how it is affected by climate change by meeting at least two of three performance indicators.

NASA achieved the annual performance goal with a rating of green. Ice sheet and glacier flow is responsible for nearly all of the ice loss in Antarctica and roughly half in Greenland. Antarctica appeared very dynamic, losing ice in the west and gaining ice in other areas. In addition, data suggested melting beneath floating ice shelves contributed substantially to the loss of ice in Antarctica. This proved the most comprehensive assessment of the ice sheet's mass balance to date. Scientists also made progress in modeling ice stream behavior in Greenland using airborne radar data that sees into the ice. The technique uses new data in a new way, and identified a cause for enhanced sliding to be melting at the bottom of the ice stream (more than 1 kilometer thick), possibly caused by heat from the Earth's interior.

Indicator 1. Map the surface velocities at their outlets of at least 10 major outlet glaciers draining West Antarctica and at least 10 outlet glaciers draining East Antarctica and determine the positions where these glaciers start to

float with a precision of 100 meters. Submit these maps for publication

Results. Researchers mapped the velocities in the northern part of the West Antarctic ice sheet, which showed ice losses. Mapping showed ice accumulated in the western part. Ice in East Antarctica appeared in balance within the certainty of measurements. In sum, the results suggested a net loss of ice in Antarctica, which is a result of the velocities draining ice faster than precipitation accumulation replace it. In addition, scientists found that melting underneath the floating ice shelves in Antarctica is roughly an order of magnitude greater than previously thought.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The journal Science published the experiment findings (Rignot and Thomas) on August 30, 2002, and in Annals of Glaciology (Rignot et al.) in August 2002.

Indicator 2. Compare new estimates of ice discharge of 20 or more Antarctic glaciers with interior mass accumulation to provide the first estimates of mass balance for their grounded ice catchments. Submit these estimates for publication

Results. NASA achieved the indicator. See indicator 1.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The journal Science published the experiment findings on August 30, 2002 (Rignot and Thomas) and in July 2002 (Rignot and Jacobs); they also appeared in Annals of Glaciology in August 2002 (Rignot et al.).

Indicator 3. Establish a methodology for refining ice stream models based on radar sounding, surface velocity and surface topographic observations. Generate a technical report for peer review

Results. Researchers derived a method for analyzing radar-derived internal layering to determine flow characteristics. Applying the method to the Northeast Greenland Ice Stream led to the discovery of a very high geothermal heat source that is causing lubrication at the base of the ice sheet, enhancing sliding.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The results (Fahnestock et al.) appeared in the journal Science in December 2001 and the Journal of Geophysical Research in December 2001.

Annual Performance Goal 2Y15. Increase understanding of the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality by meeting at least four of five performance indicators.

NASA achieved the annual performance goal with a rating of green. The Southern Hemisphere Additional Ozonesondes (SHADOZ) project continued its successful augmentation of balloon-borne launches and data archiving. SHADOZ will provide a profile climatology of tropical ozone while assisting in the validation and improvement of ozone profile data from satellite remote sensing measurements. The latest data helped evaluate the current concentration and possible trends in this atmospheric region. With the rapid diminishment in methyl chloroform abundance, trend data for new industrial chemicals are being analyzed as potential new hydroxyl (OH) estimation gases. The completion of a coupled aerosol-chemistry-climate model means processes can be evaluated in transient climate simulations. A new method assessing the amount of ozone brought from the stratosphere into the troposphere at mid-latitudes more precisely computes an exchange rate.

Indicator 1. Continue and extend the 3-year data record in order to build climatology of the high resolution vertical distribution of ozone in the tropics to improve the retrievals of tropospheric ozone concentrations based on the residual products from space-based observations

Results. A recent announcement confirmed that the SHADOZ Network received a favorable review. SHADOZ investigators participated in an international ozone sonde intercomparison to establish consistent standard operating procedures among ozone sonde researchers.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The SHADOZ project homepage provides information on news, data, and collaborations: http://code916.gsfc.nasa.gov/Data_services/shadoz/. The following journal article is in press:

Thompson, A.M., et al., 1998-2000 SHADOZ (Southern Hemisphere Additional Ozonesondes) Tropical Ozone Climatology. 1. Comparisons with TOMS and Ground-based Measurements, Journal of Geophysical Research—Atmospheres, in press, 2002.

Indicator 2. Archive and analyze data from the TRACE-P airborne mission and associated data sets to characterize the atmospheric plume from East Asia and to assess its contribution to regional and global atmospheric chemical composition

Results. The files were archived and publicly released. A second workshop was held in June. A special session dedicated to the TRACE-P results was held at the fall 2002 American Geophysical Union Meeting. Analyses are ongoing with draft manuscripts being developed. A

peer-reviewed journal published the collection of TRACE-P manuscripts.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The Journal of Geophysical Research published a special section containing the collection of TRACE-P manuscripts.

Indicator 3. Estimate the tropospheric distributions of OH and examine the consistency between inverse and assimilation models in determining global OH fields using multiple data sets; document via submission of one or more publications to peer-reviewed literature

Results. Earlier OH estimates provided information to update the latest AGAGE data. The results will appear in the 2002 international ozone assessment, as well as other publications.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The AGAGE project homepage provides information on news, data, and collaborations are located at http://agage.eas.gatech.edu/.

Examples of publications include:

Prinn et al., 2000: A History of Chemically and Radiatively Important Gases in Air deduced from ALE/GAGE/AGGE, Journal of Geophysical Research, 105, 17,571-17,792.

Cunnold, D.M., R. F. Weiss, R. G. Prinn, D. E. Hartley, P. G. Simmonds, P.J. Fraser, B. R. Miller, F. N. Alyea, and L. Porter, GAGE/AGAGE measurements indicating reduction in global emissions of CCl3F and CCl2F2 in 1992-1994, Journal of Geophysical Research, 102, 1259-1269, 1997.

Indicator 4. Simulate changes in atmospheric composition projected over the 21st century with a coupled aerosol-chemistry-climate general circulation model including projected changes in anthropogenic emissions. This model, which will include first-time parameterization of tropospheric aerosol chemistry, will help to diagnose the climatic consequences of these emissions and the associated feedbacks on atmospheric composition

Results. A coupled aerosol-chemistry-climate model has been developed that incorporates detailed representations of gas-phase and aerosol chemistry into the NASA/Goddard Institute for Space Studies (GISS) general circulation model. Early applications of this model to future radiative forcing by tropospheric ozone and aerosols in scenarios with 2,100 emissions were reported in the Intergovernmental Panel on Climate Change (IPCC) 2001 report. Application of this and other model versions to 2000-2100 transient climate calculations is ongoing. These developments complete the essential model components in that all the critical aerosol-chemistry-climate processes are represented in a single model and can be evaluated in 2000-2100 transient climate simulations.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. A general description and more than 20 publications related to this activity are located at http://www-as.harvard.edu/chemistry/trop/ids.html.

Indicator 5. Estimates of the stratospheric contribution to tropospheric ozone will be made through chemical transport and Lagrangian transport models. The stratosphere-troposphere exchange included in these model calculations will be examined for its sensitivity to global warming

Results. A new method assessing the amount of ozone brought from the stratosphere into the troposphere at mid-latitudes more precisely computes an exchange rate using the Data Assimilation Office meteorological products. These estimates are on the low side. Previous estimates made using various models and much lower than tropospheric chemical transport model parameterizations. The findings are that the higher ozone transport in the Northern Hemisphere is caused by the higher amounts of ozone in the lower stratosphere in late winter compared with the Southern Hemisphere. The mass exchange is nearly equivalent in both hemispheres. Two-dimensional model work on the effect of increasing greenhouse gases on stratospheric circulation and chemistry showed increasing greenhouse gases speeds up the recovery in the upper stratosphere and slows the recovery in the lower stratosphere because of a combination of circulation changes and the effect of temperature changes on the photochemical production rates.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The data source is Olsen et al., Journal of Geophysical Research, 2002 (in press).

Strategic Objective 4. Identify the consequences of change in the Earth system for human civilization

Annual Performance Goal 2Y16. Increase understanding of variations in local weather, precipitation, and water resources and how they relate to global climate variation by meeting two of two performance indicators.

NASA achieved the annual performance goal with a rating of green. This activity helped determine the effect of climate trends in the frequency, strength, and path of weather systems, which produce clouds and rain and

replenish fresh water supplies. Progress was made with data assimilation algorithms that assimilate TRMM data into weather and climate models. The combination of TRMM data and advanced modeling and data assimilation system achieved measurable improvements in hurricane track forecast.

Indicator 1. Characterize the interannual variations of deep tropical convection utilizing existing and new satellite-based datasets to understand relations between large-scale surface and atmospheric forcing and tropical forcing and submit results for publication

Results. Progress was made in using TRMM data to monitor convection and rainfall variations in the Tropics associated with El Niño/La Niña over the past 4 years. The variations were used to relate to previous satellite data used to analyze previous ENSO variations.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The variability of South American convective cloud systems and tropospheric circulation between January and March of 1998 and 1999 appeared in a paper submitted for publication in the Monthly Weather Review. A peer-reviewed paper in the Journal of Geophysical Research documented the impact of sub-monthly variability of the South Atlantic convergence zone on convection over the Southern Amazon Basin.

Publications include: Curtis, S., R. Adler, G. Huffman, D. Bolvin, and E. Nelkin, 2001: Global precipitation during the 1997-98 El Niño and initiation of the 1998-99 La Niña. International Journal of Climatology 21, 961-971.

Adler, R.F., C. Kummerow, D. Bolvin, S. Curtis, C. Kidd, 2002. Status of TRMM Monthly Estimates of Tropical Precipitation, Meteorological Monographs, Symposium on Cloud Systems, Hurricanes and TRMM (in press).

Indicator 2. Demonstrate impact of assimilation of TRMM rainfall data on forecasting track and intensity of tropical storms by showing improvement in near real-time hurricane and typhoon forecasts in a variety of cases and conditions

Results. The use of TRMM rainfall data in numerical models improved hurricane track forecasting in Goddard Space Flight Center (GSFC) case studies. Experiments at Florida State University also indicated positive impact of rainfall information on track forecasts. A manuscript is in preparation.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Peer-reviewed scientific literature documented the results. The citations are available on file at NASA Headquarters with the Global Modeling and Analysis Program Manager. NASA Seasonal-to-Interannual Prediction Project (NSIPP) Climate Models: Progress on climate model predictions is located at http://nsipp.gsfc.nasa.gov/exptlpreds/exptl_preds_main.html. Goddard Cloud Resolving Model and TRMM data analysis: Progress on cloud model predictions and contribution to climate model studies is located at http://rsd.gsfc.nasa.gov/912/model/model.html.

Annual Performance Goal 2Y17. Increase understanding of the consequence of land cover and land use change for the sustainability of ecosystems and economic productivity by meeting at least two of three performance indicators.

NASA achieved the annual performance goal with a rating of green. A book compiling the publications of the case studies produced under the NASA Land Cover Land Use Change Program is in its last stage of preparation. In particular, studies of patterns in land cover and land use changes in Amazon region allowed development of prediction scenarios and their evaluation. The scientific network in the Amazon region is one example of the global science network system that international projects, such as the Global Observation of Forest Cover and Land cover dynamics, are developing. Along with the well-established networks in Africa and Asia, new networks, such as in Russia, produced new links and contributed to the study of land cover and land use change.

Indicator 1. Release a document describing the first set of regional land cover and land use change case studies and providing a synthesis of their results

Results. NASA achieved this indicator. A book in preparation is based on publications from several projects including (1) Landscape Dynamics and Land-Use Land-Cover Change in the Great Basin-Mojave Desert Region, (2) Regional NPP and Carbon Stocks in Southwestern USA Rangelands: Land-use Impacts on the Grassland-Woodland Balance, (3) Developing Land Cover Scenarios in Metropolitan and Non-Metropolitan Michigan, USA: A Stochastic Simulation Approach.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The publication list is provided in the results section of annual performance goal 2Y8, indicator 1.

Indicator 2. Develop models incorporating the biophysical, socio-economic, institutional, and demographic determinants of land use and land cover change in Amazonia

Results. Progress on this indicator followed from the results of LBA-ECO Program. The team successfully analyzed parts of the Amazon and extracted statistically independent predictors of land use and land cover change. In a

separate project, researchers used differences in soil quality to explain important differences in rates of secondary succession across regions. Further, the team developed and tested a fractional cover algorithm, and assessed availability of other algorithms for project products.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Some examples of journals that published informatoin about this indicator include: Laurance, W. F., Albernaz, A. K. M. and Da Costa, C., 2001: Is deforestation accelerating in the Brazilian Amazon? Environmental Conservation. 28, 305-311.

Moran, E.F. et al. Effects of soil fertility and land use on forest succession in Eastern Amazonia, Brazil. Forest Ecology and Management. (In press)

Indicator 3. Enable the scientific interchange of data, methods, and results through the operation of regional networks of scientists in four major regions of the world

Results. In FY 2002, three regional networks were enhanced and the Russian network was established. The fire-monitoring network is being formed, and the land cover network will be formed soon. The NASA Scientific Data Purchase Program acquired a series of images for Central Africa and distributed them to in-country collaborators in order to implement local-scale land cover mapping activities. The proposed development of the regional information network will help integrate all extant data sets into the framework of Global Observation of Forest Cover. The network will synthesize and update the region-specific requirements for observations and products, work with government agencies to improve access to data, and help coordinate regional research agendas with global remote sensing community.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. See the LCLUC Web site for the project description and publications: http://lcluc.gsfc.nasa.gov/.

Annual Performance Goal 2Y18. Increase understanding of the consequences of climate and sea level changes and increased human activities on coastal regions by meeting two of two performance indicators.

NASA achieved the annual performance goal with a rating of green. Our remote sensing ability in coastal regions improved in FY 2002. NASA and commercial remote sensors mapped coral reef and they made a substantial effort to map them at smaller spatial scales. The fluorescence line-height measurements from both Terra and Aqua MODIS instruments provided a method for separating living phytoplankton from non-living particles. New numerical techniques for retrieving suspended solids in these coastal areas and efforts to correct for the atmospheric component in ocean color signals when viewing coastal regions made the improvements possible.

Indicator 1. Increase the coverage of space-based maps of coral reef distribution by 25 percent beyond current estimates using remotely sensed imagery

Results. In achieving this indicator, NASA and NOAA investigators generated 1-kilometer maps of potential coral reef habits using SeaWiFS data. The investigators compared previous coral reef maps to produce a more accurate assessment of spatial extent and geographic location of these reefs. In addition, the purchase of IKONOS—a hyperspatial satellite sensor—imagery through our Landsat data buy program permitted NOAA investigators to map coral reefs at a higher spatial resolution with improved classification algorithms.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The following is an example of a journal that published information about the indicator: Robinson, J., A. Spraggins, K.P. Lulla, S. Andréfouët, G.C. Feldman, N. Kuring, J.K. Oliver, M. Noordeloos, J.C. Brock, J. Gebelein, E.P. Green, M.D. Spalding, R.P. Stumpf, S.O. Rohmann, and M. Atkinson, 2002: Distributing reef maps to resource managers: bridging the gap between detailed remote sensing mapping and global applications. Seventh International Conference on Remote Sensing for Marine and Coastal Environments, Miami, FL. May 20-22, 2002.

Indicator 2. Develop an improved algorithm for retrievals of ocean color information from remotely sensed observations of turbid coastal systems (i.e., Case 2 water)

Results. Ocean color data in turbid coastal waters, improved atmospheric correction, and in-water algorithms provided improved algorithms. A better understanding of the optical properties in these highly heterogeneous waters and more studies of these coastal areas contributed to these improvements.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Some examples of journals that published information about this indicator include: Chomko, R.M., H.R. Gordon, S. Maritorena, and D.A. Siegel, 2002. Simultaneous determination of oceanic and atmospheric parameters for ocean color imagery by spectral optimization: A validation. Remote Sensing of Environment, (in press).

Ransibrahmanakul, V. and R.P. Stumpf. 2001. Refining SeaWiFS Vicarious Calibration Using Spectra Slopes.

American Geophysical Union, 2001 Fall Meeting. San Francisco, CA, December 10-14, 2001.

Toole, D.A., and D.A. Siegel, 2001: Modes and mechanisms of ocean color variability in the Santa Barbara Channel. Journal of Geophysical Research, 106; 26,985-27,000.

Strategic Objective 5. Enable the prediction of future changes in the Earth system

Annual Performance Goal 2Y19. Increase understanding of the extent that weather forecast duration and reliability can be improved by new space-based observations, data assimilation and modeling by meeting at least two of three performance indicators.

NASA achieved the annual performance goal with a rating of green. This activity improved the accuracy of short-term weather predictions and increased the period of validity of long-range forecasts for government, business, and individuals to help them protect lives and property and make investment decisions.

Indicator 1. Determine tropical mean convection structure (fraction of convective vs. stratiform rainfall) for the first time using TRMM's first three years of data and submit results for publication

Results. Researchers determined the fraction of rain that is convective and the fraction that is stratiform using TRMM data. They submitted their findings for publication.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Report on stratiform rain in the tropics as seen by the TRMM Precipitation Radar. Journal of Climate (submitted): Schumacher, C. and R. A. Houze, Jr., 2002.

Indicator 2. Define the quantitative requirements for new operational sensors, including space-based tropospheric winds through participation in inter-agency Observing System Simulation Experiments (OSSE)

Results. The NASA Data Assimilation Office, NESDIS (National Environmental Satellite, Data, and Information Service/NOAA), and NCEP (National Centers for Environmental Prediction/NOAA), conducted a series of Observing System Simulation Experiments. The organizations defined requirements for Global Tropospheric Wind Sounding. In addition, new meteorological metrics of OSSE have direct importance to the public, the economy, and the Government. In particular, the potential effect of Global Tropospheric Wind Sounding and other advanced sounders was evaluated with respect to landfall of hurricanes, and the prediction of intense extra tropical cyclones such as northeasters.

Data Quality. The outcomes reported accurately reflect performance and achievements in FY 2002.

Data Sources. The data used were simulated using actual satellite-based measurements and field-experiment-based measurements of cloud properties and aerosols.

Indicator 3. Develop new analysis methods that integrate global observations from the complete suite of satellite (and conventional) weather measurements into a single, self-consistent analysis of water-related phenomena (diabatic heating by radiation and precipitation, water vapor and clouds, inference of water and energy fluxes and transports). This development provides for developing requirements for new satellite sensors and new data assimilation techniques

Results. Information from multiple instruments on TRMM (microwave and infrared) was combined using a new algorithm to estimate longwave, shortwave, and latent heat fluxes and compared to top of atmosphere radiative fluxes from the TRMM CERES instrument. Additional analysis will be needed.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Some examples of journals that published information about this indicator include: Report on monitoring the Earth's energy Budget in the TRMM/GPM Era Presentation at TRMM International Science Conference, Honolulu, HI.

L'Ecuyer and G. Stephens, 2002: Monitoring the Earth's energy budget in the TRMM/GPM Era Presentation at TRMM International Science Conference, Honolulu, HI.

Annual Performance Goal 2Y20. Increase understanding of the extent that transient climate variations can be understood and predicted by meeting at least four of five performance indicators.

NASA achieved the annual performance goal with a rating of green. This activity contributed to the ability to predict global and regional climate on seasonal-to-interannual time scales with sufficient accuracy for concerned socioeconomic interests. The predictions helped people estimate the likely effects of climate variations, such as those associated with El Niño/La Niña, and issue warnings and make appropriate contingency plans. NASA developed coupled land-atmosphere-ocean model capabilities, and produced and contributed the model forecasts to national and international organizations with planning and warning responsibilities. Team members published their findings in peer review journals describing the analysis and diagnosis of climate variations using NASA Seasonal-to-Interannual Prediction Project model data.

Indicator 1. Document in the peer-reviewed literature the quantified impact of satellite altimeter observations on improving 12-month El Niño forecasts with a state-of-the-

art coupled ocean-atmosphere-land model by comparing model predictions initialized with in-situ data and both with and without satellite altimeter data

Results. C.L. Keppenne and M.M. Rienecker wrote "Multivariate assimilation of altimetry into an OGCM with diagnostic sea surface height using the ensemble Kalman filter," documenting assimilation of altimeter data into the ocean model used for NSIPP forecasts. In addition, an improved ocean model solved problems in the eastern Pacific. Progress was made in using altimetry to initialize ensembles of coupled ocean-atmosphere forecasts. A lack of knowledge of mean sea level hampered improvement over conventional data. This is being addressed through bias correction techniques.

Data Quality. The results appeared in the proceedings of the Symposium on Observations, Data Assimilation and Probabilistic Prediction (Keppenne and Rienecker), January 13-17, 2002, 158-163, American Meteorological Society.

Data Sources. The forecasts related to experimental seasonal climate predictions are located at http://nsipp.gsfc.nasa.gov/exptlpreds/exptl_preds_main.html.

The improved atmospheric model climatologies are located at http://nsipp.gsfc.nasa.gov/research/atmos/descrip/atmos_descr.html.

Coupled and component model simulations are available through http://nsipp.gsfc.nasa.gov/data_req/data_req_main.html.

Indicator 2. Contribute to national seasonal forecasts by delivering ensembles of forecast products (for example, surface temperature, precipitation, upper level winds) to Operational agencies (for example, NCEP, International Research Institute (IRI)). Forecasts with and without the use of satellite-based data will be used to document the impact of such remotely sensed data on forecast quality

Results. NASA's Seasonal-to-Interannual Prediction Project delivered forecast products (surface temperature, precipitation, upper level winds) on a monthly basis to NCEP/Climate Prediction Center (for example, http://www.emc.ncep.noaa.gov/cmb/atm_forecast/consortium/intro.html), the IRI (for example, http://iri.columbia.edu/forecast/climate/), and NOAA/Centers for Disease Control and Prevention. The experimental predictions are located at http://nsipp.gsfc.nasa.gov/exptlpreds/exptl_preds_main.html. The Asia-Pacific Climate Network also uses these forecasts on a quarterly basis. NASA's estimates of satellite-based surface winds, AVHRR sea surface temperature, and SeaWiFS data sets were used. The NSIPP made substantial advances in improving the model forecast with improved models and began using satellite altimetry data for initializing and validating model-skills. Ensemble forecasts assessing the forecast reliability over the past 8 years represented a major advancement. Other achievements included progress was on many aspects of the performance of the coupled model, the forecasts, and the ocean assimilation to incorporate satellite altimetry data.

Data Quality. The science outcomes accurately reflect performance and achievements in FY 2002.

Data Sources. The NSIPP experimental predictions are available at http://nsipp.gsfc.nasa.gov/exptlpreds/exptl_preds_main.html.

The experimental data allowed the NSIPP science team members to analyze model prediction results, study the model behavior, and provide suggestions to the core model development team.

Indicator 3. Estimate and document potential predictability, based on multi-year reanalysis data and modeling, of regional climate variability in order to evaluate the relative contributions of seasonal-to-interannual and decadal climate variability on specific regions, with a focus on occurrence of major floods and droughts in North America and the Asian-Australian monsoon regions

Results. An ensemble of 70-year NSIPP atmospheric simulations with observations, including the upper level winds from the NCEP/U.S. National Center for Atmospheric Research (NCAR) reanalysis, provided the basis for an assessment of the predictability and causes of long-term (decadal) drought over the U.S. Great Plains. Researchers confirmed a link to tropical Pacific sea surface temperature (SST). However, predictability associated with SST proved modest with about two-thirds of the signal related to interactions with soil moisture. The Journal of Climate received a paper submission describing these results.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Publications include: Schubert, S., M. J. Suarez, P. Pegion and M. Kistler, and A. Kumar, 2002: Predictability of Zonal Means During Boreal Summer, Journal of Climate 15, 420-434.

A list of other peer-reviewed publications is available at http://nsipp.gsfc.nasa.gov/pubs/pubs_main.html.

Indicator 4. Develop, implement, and document advanced cloud radiation and moist physics schemes in NASA climate models, and validate them against remotely-sensed radiation data, in order to improve overall skill of climate model simulations of the global energy and water cycles

Results. Cloud resolving (processes) model simulations provided a better understanding of precipitation efficiency and surface energy budget associated with convection developed over very different geographic locations (that is, South China Sea, West Pacific Ocean, East Atlantic Ocean, Mid-U.S.A.). Researchers used the simulations to

examine and verify the hypothesis associated with climate variations to show that the convective momentum transport processes and their interaction with ocean surface is responsible for simulating different tropical climate regimes. The simulations also allowed them to demonstrate that the microphysics and its interaction with radiation cannot alter the simulated tropical climate regime (from warm to cold), but it can change the degree of climate (from warm to warmer).

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The following is an example of a journal that published information about the indicator: Tao, W.K., Y. Wang, J. Qian, W. K.M. Lau, C.L. Shie, and R. Kakar, 2002: Mesoscale Convective Systems during SCSMEX: Simulations with a Regional Climate Model and a Cloud-Resolving Model, INDO-US Climate Research Program, (in press).

Indicator 5. Use multiyear satellite observations of lightning to assess the relationship of strong convection to interannual climate variations (for example, El Niño and La Niña), and use as proxy data to assist in evaluating model representation of convective precipitation. Document results

Results. The Optical Transient Detector and Lightning Imaging Sensors on low-Earth orbiting satellites enabled multiyear observations of global lightning distributions. The study found lightning varies seasonally and is primarily related to storms containing ice particles. NASA used high-altitude aircraft and observations from the Space Shuttle, as well as recent unmanned aerial vehicle measurements to gain understanding of the complicated micro-physical and electrical processes involved with the discharges. NASA advances in the last 5 years improved quantitative understanding of the Earth's electrification more than the previous 100 years of more limited storm-scale research. The study established the relationship between lightning flash rate and precipitation rate of convective storms and led researchers to the conclusion that lightning rate can be a proxy for precipitation rate under certain circumstances. The relationships to longer-time-scale events such as El Niño and La Niña are under study. It will take many years of continuous lightning monitoring to establish the relationship to a process as slowly varying as El Niño.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The Journal of Atmospheric Science published the improved NSIPP atmospheric model. The Journal of Climate published information on seasonal predictability for boreal summer. The Journal of Climate received a paper for publication concerning the predictability on longer timescales associated with long-term drought conditions over the U.S. Great Plains. The NSIPP 2001 contained information on altimetry assimilation. The annual report is available at http://nsipp.gsfc.nasa.gov/pubs/pubs_main.html and in the American Meteorological Society Proceedings. Other results listed above appeared in several published papers in peer-reviewed scientific literature. The citations are available on file at NASA Headquarters with the Global Modeling and Analysis Program Manager.

The research results from the lightning measurements are available on the Internet at the Global Hydrology and Climate Center.

Annual Performance Goal 2Y21. Increase understanding of the extent that long-term climate trends can be assessed or predicted by meeting at least four of five performance indicators.

NASA achieved the annual performance goal with a rating of green. NASA made progress in several areas this year. Activities concentrated at NASA GISS. Many journals published quantitative analyses of climate forcings and climate change trends. We again led the world in increasing the understanding of the forcing and trend of the long-term climate.

Indicator 1. Monitor global tropospheric and stratospheric temperatures, to validate climate model simulations, and to improve understanding of the relationship between surface and upper-air temperatures in a changing climate system. Document results

Results. GISS research found the observed stratospheric cooling and tropospheric warming consistent with and accounted for by known climate forcings, especially changes in carbon dioxide, ozone, and stratospheric water and aerosols. All of the results listed in this annual performance goal appeared in several published papers in peer-reviewed scientific literature.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The citations are available on file at NASA Headquarters with the Global Modeling and Analysis Program Manager. Progress on climate modeling is located at http://www.giss.nasa.gov/research/modeling/. GISS climate data is available at http://www.giss.nasa.gov/data/.

Indicator 2. Quantify and document the likely contributions of different climate forcings (greenhouse gases, ozone, water vapor, solar irradiance) to observed long-term trends of the Arctic Oscillation. The Arctic Oscillation has practical significance as it affects the geographical patterns of climate variability and change in the troposphere

Results. NASA GISS made quantitative analyses of this problem including investigation of the roles of specific forcings one-by-one. A peer-reviewed professional journal documented this. Another paper describing the role of volcanic aerosols in greater depth is in preparation. Evidence showed that the well-mixed greenhouse gases, especially carbon dioxide, ozone, stratospheric water, and solar irradiance changes, contributed to changes in the Arctic Oscillation.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. See indicator 1.

Indicator 3. Quantify and document the degree to which the stratosphere and mesosphere need to be incorporated and resolved in climate models to realistically simulate interannual and decadal climate variability and change in the troposphere

Results. We achieved this indicator using climate models that simulated the effect of various climate forcings extending from the upper atmosphere to at least to the top of the stratosphere. GISS investigated the potential of stratospheric models of intermediate complexity, that is, with efficient representations of stratospheric drag and without including the mesosphere. GISS showed that such efficient models, which could readily be included as part of nominally tropospheric climate models, are able to simulate well the interannual variability of stratospheric temperatures and winds, but it remains to be determined whether they can simulate well long-term climate change mechanisms involving the stratosphere.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. See indicator 1.

Indicator 4. Quantify and document the role of different forcings (greenhouse gases, ozone, water vapor, solar irradiance, stratospheric and tropospheric aerosols) and unforced (chaotic) variability in determining the evolution of global climate over the past 50 years, to develop confidence in quantitative model predictions of future climate change

Results. In the last 50 years, much of the global temperature variation at the surface, in the troposphere, and in the stratosphere, was associated with anthropogenic and natural climate forcings, especially greenhouse gases and volcanic aerosols.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. See indicator 1.

Indicator 5. Make quantitative comparisons of the ability of alternative ocean modeling treatments to simulate climate variability and change on interannual to century time scales. Document results

Results. GISS compared the results of simulations with observed SSTs, Q-flux oceans, and dynamic oceans. The comparisons provided a better understanding of these different ocean representations, offered insight for ways to improve them, and conclusions about the physical world, including the fact that the Earth was out of radiation balance with space in 1951 by about 0.18 w/m2. Journals published the finding.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. See indicator 1.

Annual Performance Goal 2Y22. Increase understanding of the extent that future atmospheric chemical impacts on ozone and climate can be predicted by meeting at least two of three performance indicators.

NASA achieved the annual performance goal with a rating of green. Newly evaluated data and the latest industry reports contributed to formulating emission scenarios for the 2002 international ozone assessment. The Global Modeling Initiative incorporated the latest set of data and improved the atmospheric models. The latest version of the model provided a simulation of 35 years of stratospheric ozone, from 1995 to 2030.

Indicator 1. Analyze the measured trends in atmospheric trace gas concentrations and compare with those estimated from industrial production and emission data. Analysis will be used to assess the completeness of our understanding of the atmospheric persistence and degradation of industrial chemicals as well as to examine the efficiency of current regulatory agreements and international reporting on the production and emissions of regulated chemicals

Results. The latest AGAGE data, industry reports of halocarbon production, and industry models of release from product applications assisted in formulating emission scenarios for the 2002 international ozone assessment.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. The AGAGE project homepage provides information on news, data, and collaborations: http://agage.eas.gatech.edu/.

Publications include: Prinn et al., 2000: A History of Chemically and Radiatively Important Gases in Air deduced from ALE/GAGE/AGGE, Journal of Geophysical Research, 105: 17,571-17,792.

Indicator 2. Conduct laboratory studies designed to assess the atmospheric fate of new industrial chemicals by characterizing the key photochemical processes responsible for their atmospheric breakdown

Results. Experiments at several NASA-funded laboratories yielded data used in the NASA Panel for Data Evaluation. Modelers who performed calculations associated with the 2002 international ozone assessment used the database.

Data Quality. The NASA Panel for Data Evaluation included members of the science community. Peer review is the most relied upon assessment of the validity of a scientific accomplishment. This report is a source of data for modelers participating in international assessments including UNEP/WMO and IPCC.

Data Sources. The NASA Panel for Data Evaluation's report is located at http://jpldataeval.jpl.nasa.gov/.

Indicator 3. Continue the implementation of the Global Modeling Initiative (GMI) to provide metrics, benchmarks and controlled numerical experiments for model and algorithm simulations performance, which will allow the development of standards of model behavior for participation in assessment exercises

Results. The GMI incorporated the latest set of fields generated by the NASA Data Assimilation Office at Goddard Space Flight Center. The initiative updated the previous stratospheric model. A team of investigators at NASA Goddard, NASA Langley, and University of Miami analyzed the results of simulation behavior in comparison to satellite and aircraft data. The findings helped define further metrics for satisfactory model behavior. The initiative also integrated a tropospheric version of the model, and incorporated the latest advances in dry and wet deposition schemes, calculation of photolysis rates, and emission inventories. A team of investigators is examining these results in comparison to ground-based observations. This analysis will establish performance metrics for tropospheric models in comparison to available data, and will reduce uncertainties in the prediction of anthropogenic activities such as aircraft and industrial emissions.

Data Quality. Peer-reviewed publication is the most relied upon assessment of the validity of a scientific accomplishment.

Data Sources. Results are located at a password-restricted file transfer protocol site at Livermore: http://esg.llnl.gov.

More publications related to the initiative are located at http://www.giss.nasa.gov/gpol/abstracts/1999/Douglass_Prather.html.

Strategic Goal 2. Expand and accelerate the realization of economic and societal benefits from Earth science information and technology

Strategic Objective 1. Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private-sector decisionmakers

Annual Performance Goal 2Y23. Provide regional decisionmakers with scientific and applications products and tools.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results segment of Part I.

Strategic Objective 2. Stimulate public interest in and understanding of Earth system science and encourage young scholars to consider careers in science and technology

Annual Performance Goal 2Y24. Share NASA's discoveries in Earth science with the public to enhance understanding of science and technology.

NASA achieved the annual performance goal with a rating of green. NASA promoted public understanding of the Earth system and collaborated with educational institutions. A wide array of learning venues attended by both adults and students used our extensive resources, including our 14 orbiting observing platforms, content, data, and expertise.

Indicator 1. Release at least 50 stories per year that cover scientific discoveries, practical benefits, or new technologies

Results. NASA achieved this indicator, releasing 112 science stories, forty-two 90-second radio stories, and 70 news releases. More than 3.3 million Americans heard each radio story. Americans also read, saw, or heard 60 percent of the 70 news releases. The rest of the world read, saw, or heard about 30 percent of the releases through newspapers, magazines, radio, television, and the Internet.

Data Quality. Radio broadcast fellowship grant reports (monthly and annual) helped validate these sources.

Data Sources. An internal report and annual and monthly grant reports provide story tracking.

Indicator 2. Sponsor assistance to at least two leading undergraduate institutions to develop courses that enable pre-service science educators to become proficient in Earth system science

Results. NASA achieved this indicator, sponsoring eight undergraduate institutions, three of which are principal sources for educators to create and/or deploy Earth system science courses targeted to undergraduates with majors or minors in science education or for master's degree students in education.

Data Quality. An independent panel of experts reviewed grant reports.

Data Sources. The courses are documented in our online database and in annual grant reports from Earth System Science Education Alliance and NOVA online, and the EdCats online database.

Indicator 3. Continue to train a pool of highly qualified scientists and educators in Earth science and remote sensing by sponsoring approximately 140 fellowships (50 of which are new) and a total of 30 New Investigator Program awards

Results. We continued to train the next generation of Earth system scientists, sponsoring 149 graduate student fellows, 52 new awardees, and 41 New Investigator awards (25 of which were new).

Data Quality. Responsible organizing officials verified sponsorships.

Data Sources. Next Generation Earth System Scientists is located at http://research.hq.nasa.gov/code_y/nra/current./Fellowship-ESS02/winners.html.

Indicator 4. Work with at least one professional society to develop content standards for professional practice of Earth remote sensing

Results. NASA sponsored the National Space Grant Consortium, which addressed the foundation knowledge and concepts needed for professional practice of Earth remote sensing (land, air, water, and life). The workshop constituted the initial steps in identifying a basic competency in the professional practice of Earth remote sensing. A report from this workshop will be available in early FY 2003.

Data Quality. The science outcomes accurately reflect performance and achievements in FY 2002.

Data Sources. The data source is the Professional Practice Content Standards: Notes and minutes from the Space Grant Consortium workshop. The formal report will appear in FY 2003.

Strategic Goal 3. Develop and adopt advanced technologies to enable mission success and serve national priorities

Strategic Objective 1. Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation

Annual Performance Goal 2Y25. Successfully develop and infuse technologies that will enable future science measurements, and/or improve performance and reduce the cost of existing measurements. Increase the readiness of technologies under development, advancing them to a maturity level where they can be infused into new missions with shorter development cycles.

NASA achieved the annual performance goal with a rating of green. FY 2002 proved a productive year for the Earth Science Technology component, which met or exceeded all of its metrics. The EO–1 Program continued its technology validation mission while refocusing some of its technology validation observations to serve other post-September 11 national interests. The technology development element ensured the selection, development and adoption of technologies, which will enable mission success and serve national priorities. In FY 2002, this program advanced 41 percent of these technologies by at least one technology readiness level (TRL). Aircraft science campaigns, space flight missions, and ground system information processing benefitted from technology infusion. New measurements enhanced the performance of an existing measurement. The EO–1 mission successfully demonstrated the use of a hyperspectral (hundreds of spectral) instrument from space for both technology validation, science, and national priorities.

Indicator 1. Annually advance 25 percent of funded technology developments one TRL

Results. We surpassed the indicator target; 41 percent of funded technology development projects advanced at least one TRL in FY 2002.

Data Quality. Data quality used for these metrics proved accurate and reliable because the results underwent review and external scrutiny throughout the development process. Project executives at Earth Science Technology Office (ESTO) maintain the assessment database, which is accessible to all internal NASA project managers and program scientists and to others authorized outside NASA.

Data Sources. Data sources for this assessment include formal reports from project managers, reviews held at science and technology workshops, and an annual assessment conducted by the ESTO program manager. Other sources include the results of competitive solicitations in which NASA-developed technologies are considered for use in instrument and mission concepts and annual independent reviews held with the Technology Subcommittee of the Earth Systems Science and Applications Advisory Committee. Web information on each project is available at http://esto.gsfc.nasa.gov/ for ESTO and at http://nmp.jpl.nasa.gov/index_flash.html for the New Millennium Program. Individual project details can be found through those Web pages.

Indicator 2. Mature 2-3 technologies to the point where they can be demonstrated in space or in an operational environment

Results. Two Instrument Incubator Program projects flew successfully on Convection And Moisture EXperiment-4: Second Generation Precipitation Radar and High Altitude Monolithic Microwave Integrated Circuit Sounding Radiometer. The Low Power Transceiver (LPT) will fly on STS-107 and the Air Force Research Laboratory's XSS-11.

NASA selected LPT as a constellation cross-link communication device for the AFRL TechSat 21 mission.

Data Quality. See indicator 1.

Data Sources. See indicator 1.

Indicator 3. Enable one new science measurement capability or significantly improve performance of an existing one

Results. The Hyperion high-resolution hyperspectral imager provided a new class of Earth observation data for improved Earth surface characterization through the resolution of surface properties into hundreds of spectral bands compared with the 10 multispectral bands flown on traditional Landsat imaging missions.

Data Quality. See indicator 1.

Data Sources. See indicator 1.

Strategic Objective 2. Develop advanced information technologies for processing, archiving, accessing, visualizing, and communicating Earth science data

Annual Performance Goal 2Y26. Develop hardware/software tools to demonstrate high-end computational modeling to further our understanding and ability to predict the dynamic interaction of physical, chemical, and biological processes affecting the Earth.

The overall assessment for this annual performance goal is red. We developed a modeling test bed for Earth Science modeling challenges. World-class coupled climate models are running on the test bed system. A measurable increase in productivity was documented. However, the design of Earth Science Modeling Framework, which has the ambitious goal of uniting the Nation's climate model software infrastructure, is about one quarter behind schedule. We plan to make up with the schedule in the next year.

Indicator 1. Successfully establish networked high performance computer test bed for Earth science modeling challenges

Results. NASA installed two high-performance computer test beds to address Earth science modeling. A 1024-processor Silicon Graphics Origin 3000 entered production service at NASA Ames Research Center. A 440-processor Compaq began production at NASA Goddard Space Flight Center. The Ames system is heavily used by the Computational Technology Grand Challenge Round 3 Investigators for advanced Earth and Space modeling studies. The Goddard system is used by the NSIPP for climate change and variation studies.

Data Quality. Information about the ARC system is available at http://www.nas.nasa.gov. Information about the Goddard system is available at http://esdcd.gsfc.nasa.gov.

Data Sources. See the Earth System Modeling Framework Web site at http://www.esmf.ucar.edu for more information and for progress relative to their milestones.

Indicator 2. Finalize Earth science multidisciplinary, integrated Modeling Framework requirements by holding successful system design review

Results. This indicator was not achieved. Three teams led by the National Center for Atmospheric Research, Massachusetts Institute of Technology (MIT), and NASA Goddard were awarded cooperative agreements to develop jointly an Earth System Modeling Framework. A successful workshop on community requirements definitions was held and a document for the Earth System Modeling Framework was widely circulated for public comment. The teams completed their initial software engineering milestone and application milestone. A peer review of the framework architecture definition document was scheduled to be completed in August 2002. It is behind schedule by about 2 months. The expected completion date is in the first quarter of FY 2003.

The Computational Technologies Investigator teams developing an Earth System Modeling Framework have completed initial requirements definition for the framework, but have not completed the peer review of the framework design scheduled for August 2002.

Data Quality. See indicator 1.

Data Sources. See indicator 1.

Annual Performance Goal 2Y27. Develop baseline suite of multidisciplinary models and computational tools leading to scalable global climate simulations.

NASA received a rating of red for this annual performance goal. Because of delays in releasing the Computational Technologies Cooperative Agreement Notice (CAN) and the awarding of investigations from this notice, work in response to these indicators is 1 year out of phase. NASA expects to achieve some of the indicators in FY 2003.

Indicator 1. Attain a three time improvement over negotiated baseline for three to eight Earth science modeling codes transferred to the high performance computer test bed

Results. This indicator was not achieved because of delays in the release of the Computational Technologies Cooperative Agreement Notice, and the awarding of investigations from this notice. Work in response to these indicators is 1 year out of phase. NASA chose 7 investigator teams from 58 respondents to the Cooperative Agreement Notice. NASA gave awards to the National Center for Atmospheric Research, MIT, and NASA Goddard for an Earth System Modeling Framework, to UCLA for Expanding Interoperability in Atmospheric-Ocean Dynamics and Tracer Transports, to NASA Goddard for Land Information System and for

Infrastructure for Public Health and Environment Forecasting, and to the Jet Propulsion Laboratory for Numerical Simulations for Active Tectonic Processes: Interoperability and Performance. All teams were under contract by March 2002. Fourteen milestones were accomplished on the negotiated schedules of the teams working toward these code demonstrations. However, because of the lateness of the awards, these teams are not scheduled to achieve their code demonstration milestones until the fourth quarter of FY 2003.

Data Quality. NASA awarded the Computational Technology Cooperative Agreement Notice; the information is located at http://research.hq.nasa.gov/code_y/nra/current/CAN-00-OES-01/index.html.

Data Sources. The Computational Technologies Web site is located at http://ct.gsfc.nasa.gov/grand.st3.html.

Indicator 2. Successfully demonstrate up to three Earth science modeling codes interoperating on a functioning Modeling Framework prototype

Results. This indicator was not achieved. Please see above.

Data Quality. See indicator 1.

Data Sources. See indicator 1.

Strategic Objective 3. Partner with other agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction

Annual Performance Goal 2Y28. Collaborate with other Federal and international agencies in developing and implementing better methods for using remotely sensed observations.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results segment of Part I.

Annual Performance Goal 2Y29. Successfully develop, have ready for launch, and operate instruments on at least two spacecraft to enable Earth science research and applications goals and objectives.

NASA achieved the annual performance goal with a rating of green. Launching spacecraft with cutting-edge technology and instruments in a timely and cost-effective manner was a key element for the continued success of Earth system research and analysis. In FY 2002, four Earth observing satellites were launched. The satellites' instruments added to the 10 existing operating missions in orbit and provided users with unprecedented volumes of information and data.

Indicator 1. Successfully develop and have ready for launch at least two spacecraft

Results. NASA developed, launched, and operated the Jason, SAGE, Aqua, and GRACE missions.

Data Quality. NASA maintained a mission status list updated and reported on monthly at the Headquarters Center Program Review.

Data Sources. A list of all Earth science launches is located at http://gaia.hq.nasa.gov/ese_missions/default.cfm?transaction=Enter_ESE_Missions.

Indicator 2. At least 90 percent of the total on-orbit instrument complement will be operational during their design lifetime

Results. There are 28 NASA-funded on-orbit instruments, 27, or 96 percent, remained functional. Not included in the 27 operating instruments are 7 still operating and collecting science data aboard the Upper Atmosphere Research Satellite launched in 1991. NASA also did not include one instrument still operating on the Earth Radiation Budget Satellite, which launched in 1984.

Data Quality. The Earth Science Program Planning and Development Division maintained an instrument status list and updated it regularly. The Earth Science Resources Team Lead maintained all budgetary information. The Program Planning and Development Division maintained a mission schedule list. The Earth Science Deputy Associate Administrator for Programs validated this list monthly.

Data Sources. The Web site located at http://gaia.hq.nasa.gov/ese_missions/lau_select.cfm lists all operating satellites. A search of any satellite mission from the Web site provides current instrument status. Moreover, the Earth Science Program Planning and Development Division tracked and archived this information.

Annual Performance Goal 2Y30. Successfully disseminate Earth Science data to enable our science research and applications goals and objectives. Success will equate to meeting four of five performance indicators.

NASA exceeded the annual performance goal for the fourth consecutive fiscal year with a rating of blue. The NASA Earth Observing System Data and Information System (EOSDIS) facilitated NASA's goals by enabling the public to benefit fully from increased understanding and observations of the environment. The EOSDIS operated the EOS satellites in orbit, and retrieved flight data and converted it into useful scientific information. Development of EOSDIS was nearly completed; remaining activities are timed to provide releases to support the upcoming launches of EOS missions through Aura in 2004. NASA developed and operated EOSDIS as a distributed interoperable system that: (1) operated the EOS satellites, (2) acquired instrument (science) data, (3) produced data and information products from the EOS spacecraft, (4) archived all these and other Earth science envi-

ronmental observation data for continuing use, and (5) make all these data and information easily available for use by the research and education communities, government agencies and all those who can benefit from the data in making economic and policy decisions.

Indicator 1. Make available data on seasonal or climate prediction, and land surface changes to users within 5 days of their acquisition

Results. The average delivery time was 1.7 days compared with 2.7 days in FY 2001. Electronic subscription or user order and retrieval dominated the product delivery method.

Data Quality. The individual DAACs and Earth Science Information Partners (ESIPs) validated the data.

Data Sources. The DAACs and the ESIPs provided data from their system logs. Customer comment data came from visual inspection of emails, contact logs, and user surveys. ESDIS compiled the data.

Indicator 2. Increase by 50 percent the volume of data acquired and archived by NASA for its research programs compared to FY 2001

Results. NASA satellites and research projects produced more than a petabyte of data in FY 2002. This data doubled the volume of archived data to 2.06 petabytes to surpass the indicator measure.

Data Quality. The individual DAACs and ESIPs validated the data.

Data Sources. The DAACs and the ESIPs provided the data, which come primarily from system logs. Visual inspection of emails, contact logs, and user surveys provided customer data. The ESDIS Project compiled the data.

Indicator 3. Increase the number of distinct EOSDIS customers by 20 percent compared to FY 2001

Results. Our data centers provided data and information products to more than 3.2 million customers, 900,000 more than in FY 2001.

Data Quality. The individual DAACs and ESIPs validated the data.

Data Sources. The DAACs and the ESIPs provided the data. ESDIS Project compiled the data. System logs are the primary data source. E-mails, contact logs, and user surveys provide the information for customer comment data.

Indicator 4. Increase scientific and applications data products delivered from the EOS DAACs by 10 percent compared to FY 2001

Results. NASA data centers provided more than 26 million data and information products to customers, 11 million more than in FY 2001.

Data Quality. The individual DAACs and ESIPs validated the data.

Data Sources. The DAACs and the ESIPs provided the data. ESDIS Project compiled the data. System logs are the primary data source. Emails, contact logs, and user surveys provide the information for customer comment data.

Indicator 5. User satisfaction: increase the number of favorable comments from DAAC and ESIP users as recorded in the customer contact logs over FY 2001; decrease total percentage of order errors by 5 percent over FY 2001

Results. The Earth science data centers received 2,169 positive comments, well exceeding the goal. The DAACs have an error rate of 0.46 percent, also exceeding the goal.

Data Quality. The individual DAACs and ESIPs validated the data.

Data Sources. The ESDIS project compiled data. The DAACs and the ESIPs provided the data. System logs are the primary data sources. Visual inspection of e-mails, contact logs, and user surveys are the sources of customer comment data.

Annual Performance Goal 2Y31. Safely operate airborne platforms to gather remote and in situ Earth science data for process and calibration/validation studies.

NASA achieved the annual performance goal with a rating of green. All missions conducted on airborne platforms went safely and achieved the data collection objectives. Scientific importance, seasonal factors, the presence of collaborative observing teams, and satellite validation needs played a role in establishing research priority.

Indicator 1. Support and execute seasonally dependent coordinated research field campaigns within one-week of target departure with the aid of airborne and suborbital platforms, as scheduled at the beginning of the fiscal year

Results. NASA established the Cold Land Processes Experiment and the CRYSTAL-Florida Area Cirrus Experiment (FACE) as this year's priority campaigns for performance metrics, based on seasonal factors, collaborative observing teams, and the concurrence of the cognizant science manager. NASA incorporated the Cold Land Processes Experiment with other experiments scheduled for the same aircraft configuration/payload, time period, and geographical area. We designated the IceSAR (Synthetic Aperture Radar) mission for the DC-8 aircraft. This marked the first phase of a multiyear, multiplatform experiment, designated Intensive Observing Period-1; it concluded successfully without mishaps, and science team members have exchanged data sets internally.

The CRYSTAL-FACE mission utilized the NASA ER-2 and WB-57F, in addition to four other airborne platforms from industry, university, and federal laboratory sources. Quick-look data sets are available at http://cloud1.arc.nasa.gov/cgi-bin/view_ quicklook_links.cgi.

Data Sources. The Cold Land Processes Experiment Mission: Dryden Flight Research Center (DFRC)/Airborne Science Office maintains mission book files that contain copies of the investigator's flight request, Experimenter's Bulletins, and Daily Flight Reports. These reports document aircraft integration and flight activity. NASA identified the Cold Land Processes Experiment as Flight Request 28003, and included it in the IceSAR Mission Book.

CRYSTAL-FACE Mission: ARC/Earth Science Project Office maintains project files for all project activity, including aircraft integration and flight coordination. NASA identified the CRYSTAL-FACE mission as Flight Requests 22301 and 2M301.

The Research Division at NASA Headquarters maintains files for program direction to the Aircraft Centers, such as guidance for aircraft mission priorities, cost/schedule targets, and other performance constraints.

Data Sources. Information about the Suborbital Science Program missions, platforms, and sensors is available from the field center projects: The Ames Research Center Earth Science Project Office is located at http://www.espo.nasa.gov/; the DFRC High-Altitude Airborne Science Project Office at http://www.dfrc.nasa.gov/airsci/; Goddard Space Flight Center/Wallops Flight Facility Aircraft Operations Office at http://www.wff.nasa.gov/~apb/; and the ARC Airborne Sensor Facility at http://asapdata.arc.nasa.gov/.

Information about the performance-metric campaigns is available from the Cold Land Processes Experiment Project located at http://www.nohrsc.nws.gov/~cline/clp/field_exp/clpx_02/clpx_02.html and the CRYSTAL-FACE Project at http://cloud1.arc.nasa.gov/crystalface/.

Information about recent and current campaigns is available from the Suborbital Science Program at http://www.earth.nasa.gov/science/suborbital/.

Biological and Physical Research

Strategic Goal 1. Conduct research to enable safe and productive human habitation of space

Strategic Objective 1. Conduct research to ensure the health, safety, and performance of humans living and working in space

Annual Performance Goal 2B1. Earn external review rating of green or blue by making progress in the following research focus areas as described in the associated indicators:

- Identify and test biomedical countermeasures that will make space flight safer for humans.
- Identify and test technologies that will enhance human performance in space flight.

NASA's Biological and Physical Research Advisory Committee reviewed progress on this annual performance goal and evaluated progress as satisfactory, or green, based on the supporting metrics.

Indicator 1. Complete protocols for flight-testing countermeasure to reduce kidney stone risk

Results. Researchers completed the protocols and tested potassium citrate on 5 of the required 20 Station crewmembers. The 15 remaining crewmember tests will be conducted with future crews as they rotate on and off the Station. This study assessed the renal stone-forming potential in humans as a function of mission duration and determined how long after space flight the higher risk for stone formation exists.

Data Quality. The outcomes reported by the program scientist accurately reflect performance and achievements in FY 2002. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA investigated the countermeasures on Station Expeditions 3 and 4, and data collection continued on the Expedition 5 crew. Reports on Station research investigations are available at http://spaceresearch.nasa.gov.

Indicator 2. Develop an investigation of crew nutritional needs and metabolism status

Building on the Biomedical Research and Countermeasures Program work described in Nutrition in Spaceflight and Weightlessness Models (2000), researchers developed an investigation and made nutritional status assessments during 15-, 30-, 60-, and 90-day experiments using a ground-based simulation model of spaceflight at the Johnson Space Center.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Reports on Station research investigations are available at http://spaceresearch.nasa.gov. The investigation was described in Nutrition in Spaceflight and Weightlessness Models (Lane, Helen W. and Schoeller, Dale A. (eds.) CRC Press LLC, Boca Raton, 2000) and Chapter 5 of Isolation: NASA Experiments in Closed-Environment Living, Science and Technology Series (Lane, Helen W., Sauer, Richard L., and Feeback, Daniel L. , volume 104, American Astronomical Society, San Diego, CA, 2002).

Indicator 3. Prepare in-flight validation of cardiovascular countermeasures

Results. We prepared the in-flight countermeasures validation. Twenty subjects in short-duration (both aircraft and Shuttle) flights and 20 Station crewmembers are required to complete this study. At present, 2 of 20 short-duration astronauts completed this study.

Data Quality. The program scientist reported these results. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Because this indicator describes an ongoing investigation, the documentation is internal to NASA. The sources include proposal review and selection documentation and the proposal entitled "Test of Midodrine as a Countermeasure Against Postflight Orthostatic Hypotension" by Dr. Janice M. Yelle.

Reports on Station research investigations are available at http://spaceresearch.nasa.gov.

Indicator 4. Evaluate and provide annual report of the progress in reducing medical risk factors

Results. Understanding and developing strategies for mitigating the biomedical risks of spaceflight to humans requires a consistent and incremental program of scientific research. Progress is measured each time required data are collected on an additional subject, each time an experiment reaches completion of data for the complete sample of subjects, and when the data from multiple experiments are understood, collated, and compared with the results of other studies. In FY 2002, 17 manifested flight experiments made measurable progress in achieving this goal. NASA selected three new experiments submitted in response to NASA Research Announcement (NRA) 01-OBPR-03. Nineteen ground-based investigations made measurable progress toward the goal by performing experiments that refine understanding and lead to the honing of hypotheses that should be proposed for flight experiments. NASA selected five additional experiments either as new or renewal efforts for ground-based study.

Annual Performance Goal Trends for Biological and Physical Research

Annual Performance Goal	Performance Assessment			
	FY 1999	FY 2000	FY 2001	FY 2002
Strategic Goal 1. Conduct research to enable safe and productive human habitation of space.				
Objective 1. Conduct research to ensure the health, safety, and performance of humans living and working in space.				
2B1	●	●	●	●
2B2	●	●	●	●
Objective 2. Conduct research on biological and physical processes to enable future missions of exploration.				
2B3				●
Strategic Goal 2. Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology.				
Objective 1. Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.				
2B4				●
2B5				◆
2B6				●
2B7				●
2B8	●		■ ↓	● ↑
2B9				●
Objective 2. Develop strategies to maximize scientific research output on the Station and other space research platforms.				
2B10				●
2H13				●
Strategic Goal 3. Enable and promote commercial research in space.				
Objective 1. Provide technical support for companies to begin space research.				
Objective 2. Foster commercial research endeavors with the Station and other assets.				
2B11	●	●	●	●
Objective 3. Systematically provide basic research knowledge to industry.				
2B12				●
Strategic Goal 4. Use space research opportunities to improve academic achievement and the quality of life.				
Objective 1. Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.				
2B13	●	●	●	◆ ↑
Objective 2. Engage and involve the public in research in space.				
2B14				●

Data Quality. Progress on performance goal 2B1 was evaluated by NASA's Biological and Physical Research Advisory Committee. The committee received lists of the manifested and planned flight experiments.

Data Sources. Two solicitations for research proposals addressed medical risk factors in FY 2002. They were

International Life Sciences Research Announcement: Research Opportunities for Flight Experiments in Space Life Sciences & Space Sciences, NRA-01-OBPR-03 (ILSRA-2001), Issued May 29, 2001. Selection: January 11, 2002.

Multiple Opportunities for Ground-Based Research In Space Life Sciences, NRA-01-OBPR-07, Issued: October 31, 2001. Selection: July 31, 2002.

Annual Performance Goal 2B2. Earn external review rating of green or blue by making progress in the following research focus area:

- Identify and test new technologies to improve life-support systems for spacecraft.

NASA successfully demonstrated a 33-percent reduction in the projected mass of life support for a baselined life-support system. Despite substantial progress, including contri-

butions to a Space Radiation Health Plan and the impending release of new radiation standards from the National Council on Radiation Protection and Measurement, NASA did not release a new radiation protection plan in FY 2002. The Biological and Physical Research Advisory Committee reviewed our progress and determined that a rating of green best conveyed our performance.

Indicator 1. Office of Biological and Physical Research (OBPR), will demonstrate, through vigorous research and technology development, a 33-percent reduction in the projected mass of a life-support-flight system compared to the current (FY 2001) system baselined for the Station. The quantitative calculation of this metric will be posted on the Internet

Results. NASA achieved the indicator and posted quantitative calculations on the Internet. The 33-percent figure accounts for the state of technology development by projecting the mass of a benchmark life-support system and comparing it to the baselined Station life-support system.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The calculation and supporting documentation are located at http://advlifesupport.jsc.nasa.gov.

Indicator 2. Complete a radiation protection plan that will guide future research and development to improve health and safety for space travelers

Results. Progress toward accomplishment of the performance goal was made. While the actual completion of the plan has been delayed, its purpose was better served by a more considered approach and the time was used effectively to develop an Agency-wide understanding of radiation-related activities.

In February 2001, NASA's Chief Scientist chartered the NASA Space Radiation Research Working Group (NSRR) as the task force to coordinate all Agency-wide activities related to space radiation. The NSRR held four meetings and will meet quarterly, at a minimum, in the future. The NSRR reports to the NASA Chief Scientist and briefs the Chief Health and Medical Officer on recommendations for developing radiation health policy. The Deputy Associate Administrator for Science of the biological and physical research effort was the designated NSRR chair.

There is one representative from each of the following NASA organizations:

Bioastronautics Research Division of biological and physical research; Fundamental Space Biology Division of biological and physical research; Physical Sciences Research Division of the biological and physical research effort; Headquarters Office of the Chief Technologist; Assistant Associate Administrator for Crew Health and Safety (Office of Space Flight); Safety and Risk Management Division of the Office of Safety and Mission Assurance; Assistant Associate Administrator for Advanced System (Office of Space Flight); Sun-Earth Connection Division of space science; and the research division of the Earth science mission. There is also one representative from each of the following: Ames Research Center, Dryden Flight Research Center, Goddard Space Flight Center, Jet Propulsion Laboratory, Johnson Space Center, Kennedy Space Center, Langley Research Center, and Marshall Space Flight Center.

The state of the NSRR activities in developing an updated strategic plan for radiation health is as follows:

It was agreed that development of an Agency-wide strategic plan required a process that fully addresses the wide range of radiation-related issues with which different organizations within NASA are concerned. The development of the plan requires collection of information about these activities. This was completed. A draft of an updated strategic plan was prepared and distributed to all members. It will be discussed at the NSRR meeting in January 2003. The target date for completion and sign-off of the strategic plan by the NASA Chief Scientist is September 30, 2003.

A Radiobiology External Review Panel (RERP) was chartered by the biological and physical research Deputy Associate Administrator for Science in May 2001. This panel was intended to fulfill the role of the steering committee. It met several times and was expected to provide a final report in December 2002.

The panel co-chairs are: Elizabeth L. Travis of the MD Anderson Cancer Center and Nancy L. Oleinick of Case Western Reserve University. The RERP members include: Bruce M Coull (University of Arizona), Albert J. Fornace, (Head, Gene Response Section, National Institutes of Health), Philip J. Tofilon (MD Anderson Cancer Center), Susan S. Wallace (University of Vermont), and Andrew J. Grosovski (University of California, Riverside). Members who contributed but are no longer participating include: Claire Fraser (President, Institute for Genomic Research), Michael B. Kastan (St. Jude Children's Research Hospital), Judith Campisi (Lawrence Berkeley National Laboratory), and Esther H. Chang (Georgetown University Medical Center).

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Publications on data and plans include Radiation Protection Guidance for Activities in Low Earth Orbit, National Council on Radiation Protection and Measurement Report 132, Bethesda, MD, 2000; Operational Radiation Protection Methods for Space Flight, National Council on Radiation Protection and

Measurement Report (in press), 2002; F.A. Cucinotta, et al., Space Radiation and Cataracts in Astronauts, Radiation Research 156, 460-466, 2001; and F.A. Cucinotta et al., Space Radiation Cancer Risks and Uncertainties for Mars Missions, Radiation Research 156, 682-688, 2001. Further data are available at http://srhp.jsc.nasa.gov.

Strategic Objective 2. Conduct research on biological and physical processes to enable future missions of exploration

Annual Performance Goal 2B3. Earn external review rating of green or blue by making progress in the following research focus areas:

- Develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical process monitoring.
- Identify and study changes in biological and physical mechanisms that might be exploited for ultimate application to improving the health and safety of space travelers

The Biological and Physical Research Advisory Committee rated progress on this annual performance goal as green. This goal and the field of research were new in FY 2002.

Indicator 1. Collaborate with the National Cancer Institute to create and maintain a core program using academic, industrial, and government researchers to develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical processes

Results. The National Cancer Institute and NASA issued a joint research opportunities announcement for fundamental biomolecular sensor technology development. NASA announced awards in the first quarter of FY 2002; we funded 7 of the 55 proposals for extramural investigations. In parallel, NASA received 16 proposals for the intramural program, which focused on developing technology to support NASA's exploration goals.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The committee received a list of the selected investigators and their project titles. Summaries are available for all extramural and intramural projects on the NASA-National Cancer Institute Biomolecular Sensor Development Web site at http://nasa-nci.arc.nasa.gov/.

Indicator 2. Develop a study on the effects of space flight on bone loss as a function of age in an animal model

Results. We developed for flight the experiment "Space Flight And Bone Metabolism: Age Effects And Development Of An Animal Model For Adult Human Bone Loss," by Bernard Halloran of the University of California at San Francisco and the Veterans Affairs Medical Center. The study compared the effects of spaceflight on the bones of young rats with those of mature ones. It sought to determine whether the skeletal system of the mature rat mimics the responses of the human skeletal system to microgravity. If the mature rat and human bones respond similarly, this finding would be a boon to the study of the skeletal system in space and the development of countermeasures to bone loss in spaceflight crews.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. As noted above, this indicator describes a study that has not yet been conducted. The available documents are the products of NASA's peer-review process for selecting research.

Indicator 3. Develop studies on space-flight-induced genomics changes

Results. A series of experiments that investigate genomic changes were selected through the peer-review process and were developed for flight. The studies include examining of the effects of spaceflight on gene expression in microbial populations, identifying key genes involved in plant growth and functioning in the space environment, studying the genes associated with the response of fruit flies to space, and understanding genetic mechanisms associated with muscle atrophy and immune cell functioning in space.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal. The committee received a list of the investigations described.

Data Sources. As noted above, this indicator describes a future study. The available documents are the products of NASA's peer-review process for selecting research.

Strategic Goal 2. Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology

Strategic Objective 1. Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community

Annual Performance Goal 2B4. Earn external review rating of green or blue by making progress in the following research focus areas as described in the associated indicators.

- Advance the scientific understanding of complex biological and physical systems

The results of this annual performance goal and its associated indicators are located in the Highlights of the Most Important Performance Goals and Results segment of Part I.

Annual Performance Goal 2B5. Earn external review rating of green or blue by making progress in the following research focus areas as described in the associated indicators:

- Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures

The results of this annual performance goal and its associated indicators are located in the Highlights of the Most Important Performance Goals and Results segment of Part I.

Annual Performance Goal 2B6. Earn external review rating of green or blue by making progress in the following research focus areas as described in the associated indicators.

- Initiate a focused research program specifically integrating fluid physics and materials science with fundamental biology

NASA's Biological and Physical Research Advisory Committee declined to rate the annual performance goal in light of anticipated difficulties in 2003. The rating for this performance goal is green. This goal was new in FY 2002.

Indicator 1. Initiate the definition of a bioscience and Engineering institute to drive novel concepts for space-based investigations in biomolecular systems

Results. NASA released a Cooperative Announcement Notice for a bioscience engineering institute that would enable excellent research, development, U.S. technology transfer, and education in bioscience and engineering. It is planned to emphasize biological and physical processes and space exploration and development. NASA received 13 proposals for establishing either a single academic institution or an academic institution consortium with a clear lead institution responsible for oversight and coordination. An external peer-review panel evaluated the proposals and conducted site visits between February and May 2002. Because proposals varied from the priorities established by the Research Maximization and Prioritization Task Force Task Force (ReMaP), NASA did not select a candidate from this cooperative announcement. NASA is studying options for funding a bioscience and engineering institute consistent with Agency research priorities.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The Cooperative Agreement Notice and the other supporting data are located at http://research.hq.nasa.gov/code_u/nra/current/CAN-01-OBPR-01/index.html and http://spaceresearch.nasa.gov/general_info/remapreport.html.

Annual Performance Goal 2B7. Earn external review rating of green or blue by making progress in the following research focus area.

- Investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization

NASA's Biological and Physical Research Advisory Committee rated progress on this annual performance goal as green. This goal was new in FY 2002.

Indicator 1. Maintain an outstanding and peer-reviewed research program in condensed matter physics, Bose-Einstein Condensation, and atomic clocks development for space-based utilization

Results. The fundamental physics discipline of the Physical Sciences Research Program supported 19 investigations in laser-cooled atomic physics and 31 investigations in low-temperature condensed matter physics. The two areas accounted for 76 percent of the investigations in the discipline compared with 79 percent in FY 2001. Within the discipline, 11 flight-based investigations are in various stages of development. Included among the fundamental physics investigators are five Nobel Prize winners, most recently in 2001. Indicator 2 provides research results.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Indicator data came from the FY 2002 Office of Biological Research (OBPR) Research Taskbook, http://research.hq.nasa.gov/taskbook.cfm, which will be available to the public by February 28, 2003.

Indicator 2. Produce scientific discoveries in atomic and condensed matter physics, and publish in mainstream peer-reviewed archival journals

Results. NASA supports ground-based research in condensed matter physics that uses lasers to produce extremely cold matter which, under the right conditions, forms a new state of matter called a Bose-Einstein condensate. The atoms in a Bose-Einstein condensate function as a single entity in a way that normal matter does not (They are said to share the same quantum state.). NASA supports this cutting edge research in anticipation of similar research that will be conducted on the Station. Earth-based research is limited by the tendency of the samples to fall out of the experimental apparatus in seconds. Anything done to levitate the sample on Earth would tend to raise its temperature, but in space, samples may last for minutes or even hours. The experiments described represent substantial milestones in physicists' quest to study quantum phenomena—physical phenomena that are ordinarily only observable at microscopic scales—in macroscopic systems. This research could have far-reaching

implications for the future of information and communication technologies including next-generation computers based on quantum physics.

In FY 2002, NASA-funded research made three key discoveries in the area of Bose-Einstein condensates.

Continuing his Nobel Prize winning work, Dr. Wolfgang Ketterle and his colleagues at the Massachusetts Institute of Technology investigated vortices in the condensate. Ketterle's group created vortices in a condensate by moving a laser beam through it and then imaging its phase by interfering that condensate with a second unperturbed condensate that served as a local oscillator. These results are described in the paper "Observation of Vortex Phase Singularities in Bose-Einstein Condensates" by S. Inouye, S. Gupta, T. Rosenband, A.P. Chikkatur, A. Gürlitz, T.L. Gustavson, A.E. Leanhardt, D.E. Pritchard, and W. Ketterle, published in Physical Review Letters 87, 080402 (2001).

NASA-supported researchers at Rice University cooled lithium atoms to 1 billion times below room temperature to form a Bose-Einstein condensate. In this state, the atoms formed a soliton train of multiple waves. Dr. Randall G. Hulet co-authored "Formation and propagation of matter-wave soliton trains," which appeared in a May 9, 2002, issue of the journal Nature.

Juha Javanainen and his colleagues investigated a two-species mixture of cold Fermi-Dirac atoms. They observed fractionalization of the particle at unique sites in a one-dimensional optical lattice. This research also applied to two-dimensional and three-dimensional lattices. As described recently in the Physics Review Focus online news magazine (http://focus.aps.org/v9/st21.html), ultra-cold atoms placed in a periodic confining lattice can have partial numbers of atoms at places in the lattice where phase kinks occur. Some atoms can be located at the nodes in the potential by studying a two-species Fermi-Dirac gas in a one-dimensional optical lattice, coupled to an electromagnetic field with a phase kink. Details are in Physical Review Letters, 88, 180401 (2002).

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal. The committee received abstracts of the progress in this research area.

Data Sources. Further information on the vortex phase singularities observations is available at http://link.aps.org/abstract/PRL/v87/e080402, http://link.aps.org/abstract/PRL/v88/e090801 and http://spaceresearch.nasa.gov/general_info/OBPR-02-101.html.

Supporting information on soliton research is available at http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v417/n6885/abs/417153a_fs.html and http://spaceresearch.nasa.gov/general_info/OBPR-02-130.html.

The data sources for Fermi-Dirac atoms experiments are located at http://link.aps.org/abstract/PRL/v88/e180401.

Indicator 3. Design and develop flight experiment apparatus for low-temperature physics, laser cooling, and atomic physics investigations on the Station

Results. Low-temperature physics research exploits the microgravity environment of space to explore the basic properties of matter. In FY 2002, flight experiment apparatus were under development for experiments (Critical Dynamics in Microgravity, Microgravity Scaling Theory Experiment, and Liquid-Gas Critical Point in Microgravity) on the behavior of matter under conditions in which it can be a liquid and a gas simultaneously. Other experiments explored the properties of a form of helium, known as superfluid helium, which has extremely low viscosity and hence essentially no resistence to flowing or changes in shape (Heat Capacity of Superfluid Helium-4 in the Presence of a Heat Flux). This research probes the basic organization of matter, the nature of complexity, and the mechanisms that drive the interplay between order and disorder. The applications of this research include tests of basic theories in quantum mechanics and the results could lead to improved models of complex phenomena (such as the weather or the economy) at many different scales.

The Low Temperature and Microgravity Physics Facility (LTMPF) project continued progress in all design and development areas. The facility's preliminary design review was completed and the project continued on to the implementation phase. Proposed experiments for the first flight have received authority to proceed into the implementation phase. A combined science concept review and requirements definition review for two add-on experiments was held in April. One received authority to proceed for flight development, while a second awaits a decision based on more science data published by late 2002. Some hardware procurements and fabrication activities are well underway.

Researchers are working to use the unique environment of space to produce super accurate atomic clocks. Such clocks, which may measure the passage of time even more accurately than current atomic clock technology, would serve as instruments for fundamental research on time, matter, and relativity. They would also have important applications for navigation in space, improved global positioning systems, and improved global and wireless communication technologies. With rapid advances in computation and communication technology, an improved time standard could have countless applications.

Our work on laser cooling and atomic physics investigations made progress in FY 2002. We put in place the core engineering team for the Primary Atomic Reference Clock in Space experiment and worked on determining preliminary subsystem designs. A successful 2-day peer

review examined the subsystem requirements and evaluated progress toward solving technical challenges. Researchers developed a ground test bed for rapid prototyping and evaluation of designs. In a second experiment using a rubidium atomic clock, a conceptual design for a high-power 789-nanometer laser system was developed.

Data Quality. NASA's Biological and Physical Research Advisory Committee reviewed progress toward accomplishing performance goal 2B5. The committee does not necessarily review individual experiments but is provided with summary information and the Web address for abstracts and citations for this indicator

Data Sources. The program scientist reported results for this indicator.

Annual Performance Goal 2B8. Earn external review rating of green or blue by making progress in the following research focus area.

- Investigate fundamental and unresolved issues in fluid physics, and materials and combustion science using gravity as a theoretical and experimental revealing tool

NASA's Biological and Physical Research Advisory Committee rated progress on this annual performance goal as green. The rating improved from a red in FY 2001. NASA accomplished all of the indicators related to fluid physics and combustion science.

Indicator 1. Maintain an outstanding and peer-reviewed program in fluid physics, and materials and combustion sciences

Results. The fluid physics, materials science, and combustion science disciplines supported 317 investigations, 62 percent of the total in the physical sciences, compared with 342 investigations in FY 2001, also 62 percent of the total. NASA-supported researchers received three honors in combustion research. The National Academy of Engineering elected Princeton University's Dr. C.K. Law. He also won the American Institute of Aeronautics and Astronautics' best paper award. The U.S. National Academy of Engineering inducted Professor Felix Weinberg of the Imperial College London.

NASA-supported researchers received five honors in fluids physics area. The American Society of Mechanical Engineers elected Dr. Paul Neitzel of Georgia Tech a fellow. The American Physical Society elected Dr. John Goree of the University of Iowa a fellow. Dr. Gary Leal, of the University of California at Santa Barbara, won the American Physical Society's prestigious Fluid Dynamics Prize for 2002. ASM International named NASA Glenn's Dr. Walter Duval a fellow. Dr. Andreas Acrivos of City College of New York won the President's National Medal of Science.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Data for this indicator came from the FY 2002 OBPR Research Taskbook, http://research.hq.nasa.gov/taskbook.cfm, which will be available to the public by February 28, 2003.

Indicator 2. Complete the preparation for Station investigations in fundamental materials science to be carried out in the Microgravity Science Glovebox

Results. STS-111 delivered the hardware for the Solidification Using a Baffle in Sealed Ampoules experiment. Researchers will conduct the experiment inside the Microgravity Science Glovebox in FY 2003. Investigators added tellurium and zinc to molten indium antimonide specimens and cooled them to form a solid single crystal by a process called directional solidification. To control the optoelectronic properties of the crystals, researchers added a small amount of an impurity—called a dopant—to the pure semiconductor. Uniform distribution of the dopant is essential for production of optoelectronic devices. The goals of this experiment are to identify what causes the motion in melts processed inside space laboratories and to reduce the magnitude of the melt motion so that it does not interfere with semiconductor production.

The same mission delivered to the Station the Pore Formation and Mobility During Controlled Directional Solidification in a Microgravity Environment experiment. Through this investigation, we will observe bubble formation in the samples and study their movements and interactions. Ultimately, the goal is to improve the production of uniform composites.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The data sources for the glovebox experiments are located at http://www1.msfc.nasa.gov/NEWSROOM/background/facts/SUBSA.html; http://spaceresearch.nasa.gov/research_projects/ros/subsa.html; http://www1.msfc.nasa.gov/NEWSROOM/background/facts/PFMI.html; and http://spaceresearch.nasa.gov/research_projects/ros/pfm.html.

Indicator 3. Prepare two major space-based combustion research experiments for flight on the Space Shuttle

Results. The Laminar Soot Processes experiments aboard the Shuttle will use the microgravity environment to eliminate buoyancy effects and slow the reactions inside a flame for easier study. This classical flame observed in microgravity approximates combustion in diesel engines, aircraft jet propulsion engines, and furnaces. The experiments will expand on prior data suggesting the existence of a universal relationship, or soot paradigm, that would be used to model and control combustion systems on Earth. In addition, they will help set the stage for extended combustion experiments aboard the Station.

NASA prepared a second experiment, Structure of Flame Balls at Low Lewis-number–2, or SOFBALL–2, which will help improve our understanding of the flame ball phenomenon; determine the conditions under which flame balls exist; test predictions of flame ball lifetimes; and acquire better data for critical model comparison. Flame balls—the weakest fires in space or on Earth—typically produce 1 watt of thermal power compared to the 50 watts a birthday candle generates. The Lewis-number measures the rate of diffusion of fuel into the flame ball relative to the rate of diffusion of heat away from the flame ball. Lewis-number mixtures conduct heat poorly. Hydrogen and methane are the only fuels that provide low enough Lewis-numbers to produce stable flame balls, and even then only for very weak, barely flammable mixtures. In space, flame balls give scientists the opportunity to test models in one of the simplest combustion experiments possible. What we learn is applicable to managing and using combustion in many other processes.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. A description of the laminar soot experiments is located at http://spaceresearch.nasa.gov/sts-107/107_lsp.pdf. Information on the SOFBALL–2 studies is located at http://spaceresearch.nasa.gov/sts-107/107_sofball.pdf and http://spaceresearch.nasa.gov/general_info/21aug_flameballs.html.

Indicator 4. Initiate a new annual process to solicit and select peer-reviewed, ground-based investigations in materials science, fluid physics, and combustion research

Results. NASA established the Annual NASA Research Announcement process, which solicited flight- and ground-based research for areas including biotechnology, combustion science, fluid physics, fundamental physics, and materials science, as well as special focus themes, such as materials science for advanced space propulsion.

In this process, NASA issues a research announcement once per year. The proposal due dates for each scientific discipline are staggered throughout the year. The new process was successful and allowed the Physical Sciences Research Program to make more timely adjustments to program content.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The NASA Research Announcement, Research Opportunities In Physical Sciences Physical Sciences Ground-Based And Flight Research (NRA-01-OBPR-08), is available at http://research.hq.nasa.gov/code_u/nra/current/NRA-01-OBPR-08/index.html.

Annual Performance Goal 2B9. Earn external review rating of green or blue by making progress in the following research focus area:

- Understand the role of gravity in biological processes at all levels of biological complexity.

NASA's Biological and Physical Research Advisory Committee rated progress on this annual performance goal as green. This goal was new in FY 2002.

Indicator 1. Maintain an outstanding and peer-reviewed program in fundamental space biology

Results. In FY 2002, we supported 158 investigations, of which 134 were ground-based and 24 were flight-based. A total of $16.9 million, or 51 percent of the space biology research and technology budget, directly supported these investigations. We released a solicitation for ground-based research in FY 2002. Of 100 proposals received, we funded 22.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The data for this indicator came from the FY 2002 OBPR Research Taskbook, http://research.hq.nasa.gov/taskbook.cfm, which will be available to the public by February 28, 2003.

Indicator 2. Develop and implement Fundamental Space Biology research plans to utilize early Station capability

Results. Planning for early Station utilization kicked off at a March workshop at Ames Research Center. Members of the research community, hardware developers, and representatives of the Station Program Office, Astronaut Office, and relevant advisory committees developed recommendations for program procedures, science priorities, and associated technology capability. The plans will be incorporated in future solicitations for flight experiments.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA published the results of the workshop in Workshop Report, Space Biology on the Early International Space Station Workshop, March 14-15, 2002.

Indicator 3. Determine baseline data requirements for model specimens to be used on the Station

Indicator 4. Plan for incorporation of baseline data collection in Station hardware validation flights

NASA determined baseline data requirements for the C. Elegans and yeast specimens planned for use on the Station. We will incorporate these data requirements into validation flights of Station hardware including the Biological Research Project incubator, cell culture unit, and insect habitat. This preparatory work will make pos-

sible Station experiments using animal models to pursue basic questions in biology.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The results of the workshop appeared in Workshop Report, Space Biology on the Early International Space Station Workshop, held at NASA Ames Research Center, March 14-15, 2002.

Strategic Objective 2. Develop strategies to maximize scientific research output on the Station and other space research platforms

Annual Performance Goal 2B10. In close coordination with the research community, allocate flight resources to achieve a balanced and productive research program.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results segment of Part I.

Annual Performance Goal 2H13. Demonstrate progress toward Station research hardware development.

NASA accomplished this goal by developing three U.S. provided research racks for the Station and providing integration support for delivery of two international-partner-provided research racks. The rating for this performance goal is green.

Indicator 1. Complete development of three U.S. provided research racks for the Station

Results. NASA completed development of the following three racks: Human Research Facility-2 (HRF-2), Window Observational Research Facility (WORF), and Expedite the Processing of Experiments to Space Station (EXPRESS) Rack-8 (ER-8). These racks are available for Station research in the biological, physical, and observational sciences for both commercial and academic researchers.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The HRF-2, WORF, and ER-8 Station research facility racks were developed, delivered, and accepted by the Government. Acceptance data packages (ADPs) for WORF and ER-8 are on file at the Marshall Space Flight Center, and an ADP for the HRF-2 is on file at Johnson Space Center.

Background information on the racks is located at the following Web sites:

- WORF:http://iss-www.jsc.nasa.gov/ss/issapt/rpwg/Presentations/WORF.ppt
- ER-8:http://iss-www.jsc.nasa.gov/ss/issapt/rpwg/Presentations/EXPRESS.ppt
- HRF-2: http://hrf.jsc.nasa.gov/.

Indicator 2. Provide integration support for delivery of two International Partner provided research racks for the Station

Results. NASA successfully integrated the Microgravity Science Glovebox provided by the European Space Agency into the Station, where it supports investigations in the physical sciences.

The European Space Agency also developed and delivered the Minus Eighty-Degree Laboratory Freezer for the Space Station. It is at Kennedy Space Center in preparation for launch in March 2003.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Information on the Microgravity Sciences Glovebox is available at http://spaceresearch.nasa.gov/research_projects/ros/msg.html. Information on the Minus Eighty-Degree laboratory Freezer for the Station is available at http://www.esa.int/export/esaHS/ESAJVCF18ZC_iss_0.html.

Strategic Goal 3. Enable and promote commercial research in space

Strategic Objective 1. Provide technical support for companies to begin space research

Strategic Objective 2. Foster commercial research endeavors with the Station and other assets

Annual Performance Goal 2B11. Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least three of four performance indicators

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results segment of Part I.

Strategic Objective 3. Systematically provide basic research knowledge to industry

Annual Performance Goal 2B12. Highlight Station-based commercial space research at business meetings and conferences.

NASA's Biological and Physical Research Advisory Committee rated progress on this annual performance goal as green.

Indicator 1. Support at least three business/trade conferences to highlight Station-based commercial space research

Results. At three conferences, NASA shared information on the commercial space centers' research on the Shuttle and now the Station. We expanded interaction with the commercial community at the National Association of Manufacturers conference in Chicago; the Biotechnology Industry Organization annual meeting in Toronto, Canada in June 2002; and the NBC4 Technology Showcase in Washington, DC. Several commercial space center representatives participated in a space forum in Colorado Springs, CO, making a number of useful industry contacts. Our staff highlighted areas of commercial medical research including tumor treatment using photosensitive dyes and light emitting diodes, protein crystal research, and telemedicine in an exhibit at the American Society of Clinical Oncology conference in Orlando, FL.

Data Quality. The outcomes accurately reflect performance and achievements in FY 2002. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. Commercial research program information is available at http://spd.nasa.gov.

Strategic Goal 4. Use space research opportunities to improve academic achievement and the quality of life

Strategic Objective 1. Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets

Annual Performance Goal 2B13. Provide information and educational materials to American teachers.

We reached out to teachers through our well-attended educational conferences. NASA's Biological and Physical Research Advisory Committee rated this annual performance goal as blue to indicate that NASA significantly exceeded expectations for this performance goal. NASA received green ratings in the previous three fiscal years.

Indicator 1. Develop electronic and printed educational materials which focus on biological and physical research, and distribute these materials at at least three conferences and through the Internet

Results. We achieved the indicator, holding 5 National Education Conferences attended by more than 70,000 teachers, and participating in each conference's "One NASA" exhibit. We distributed numerous educational publications. Space Research, the biological and physical effort's research newsletter, was disseminated at several conferences including the American Society of Clinical Oncology and the National Medical Association. The publication was well received and the mailing list is rapidly expanding.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The portal for biological and physical research educational materials is located at http://spaceresearch.nasa.gov.

Strategic Objective 2. Engage and involve the public in research in space

Annual Performance Goal 2B14. Work with media outlets and public institutions to disseminate OBPR information to wide audiences.

NASA's Biological and Physical Research Advisory Committee rated progress on this annual performance goal as green. This goal was new in FY 2002.

Indicator 1. Work with Public Broadcasting Service (PBS) and Discovery Channel producers to explore opportunities for TV products with space/research/microgravity themes

Results. NASA's Distance Learning at Langley Research Center began collaboration with PBS to produce a four-segment TV series and a CD-ROM that expanded on the concepts. The complete package will bring NASA information to grades kindergarten to 12 through PBS, the Web, and CD-ROM in both English and Spanish.

Data Quality. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. No publicly available data sources exist.

Indicator 2. Work with Life Science Museum Network members to explore opportunities for the development of projects, special events, or workshops focused on Life Sciences biology-related research themes to attract and engage public audiences

Results. The Life Sciences Museum Network was renamed the Space Research Museum Network to better represent our research of biological and physical sciences. A multi-media product, "Space Research and You," explained the science conducted on STS-107 to the public and educators. Museum members helped develop and pilot the product.

A museum member questionnaire formed the basis of a white paper assessment for management and the NASA Education Office. We received recommendations for bringing projects, materials, workshops, and leadership to informal science center learning institutions.

Data Quality. The outcomes accurately reflect performance and achievements in FY 2002. NASA's Biological

and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. NASA's activities with the Space Research Museum Network are located at http://spaceresearch.nasa.gov/general_info/sts107museum.html.

Indicator 3. Make available to wide audiences an online database of commercial space center activities, including publications listings, patents, and other information useful to the public

Results. NASA maintains a Web site for the commercial center program at http://spd.nasa.gov. This site provides an overview of the commercial space centers and links to each center.

The commercial space center Source book is available at http://www.spd.nasa.gov/sourcebook/index.html. It is an online database containing information about affiliates, leveraged funding from industry and other non-NASA sources, refereed and nonrefereed publications, and recent accomplishments, patents, and other indices of interest to the public and in particular to companies seeking our market data.

Data Quality. The outcomes accurately reflect performance and achievements in FY 2002. NASA's Biological and Physical Research Advisory Committee evaluated progress toward this annual performance goal.

Data Sources. The database is available at http://www.spd.nasa.gov.

Human Exploration and Development of Space

Strategic Goal 1. Explore the space frontier

Strategic Objective 3. Enable human exploration through collaborative robotic missions

Annual Performance Goal 2H3. Provide reliable launch services for approved missions.

Although this is the first year for this performance metric, NASA has a history of 59 successes out of 60 attempts to launch primary payloads on expendable launch vehicles (ELVs) since 1987. That is a 98.3 percent success rate. All five NASA-managed ELV launches of primary payloads in FY 2002 were successful. As a result, we earned a rating of green for this annual performance goal. (As noted in the Discussion section, the cancellation of the Strategic Launch Initiative caused the elimination of strategic objectives 1, 2, 4, and 5.)

Indicator 1. NASA success rate at or above a running average of 95 percent for missions noted on the flight planning board manifest and launched pursuant to commercial launch service contracts

Results. Domestic ELVs have a historical predicted design reliability of 95 percent. Demonstrated flight history varies by launch vehicle and customer and can be affected by myriad factors, including vehicle maturity, launch provider experience, clarity and adherence to procedures/process, and technical management. In the aftermath of the Space Shuttle Challenger tragedy, NASA was directed to acquire ELV launch services from the domestic launch industry to meet the needs of scientific, Earth observing, communication, and technology payloads requiring launch on a range of vehicles to a variety of orbits and destinations. Most NASA payloads flown on ELVs are unique, with an investment in resources in excess of the cost of the launch system. With the transition to acquisition of ELV services, NASA implemented an ELV technical strategy to focus government technical oversight to maximize the successful launch of NASA primary payloads on commercial systems. NASA has used this technical oversight approach for 60 missions since 1987 with 59 successful launches (98.3 percent running average). In FY 2002, all five (Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED)/Jason, Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI), Tracking and Data Relay Satellite Project (TDRS)-I, Aqua, and Comet Nucleus Tour (CONTOUR)) of the NASA-managed ELV launches for which this technical oversight approach was applied were successfully launched.

This performance indicator seeks to ensure the continued successful deployment of NASA's commercially launched primary payloads for which it exercises technical oversight (as described in the NASA Policy Directive (NPD) "Technical Oversight Policy for Launch Services" (NPD 8610.23)). The goal of a sustained demonstrated success rate of 95 percent was based on a goal to achieve the ELV predicted design reliability of 95 percent for NASA missions. This metric accepts the inherent risk of launching on an expendable vehicle and accounts for the probability that NASA missions may indeed suffer a launch failure. The running average is calculated from 1987 to the present. Launch success is defined as a payload being deployed to its required orbit by the launch vehicle within the specified contractual launch environments. NASA withholds final launch payments until after engineering and contracting officer determination of mission success.

NASA maintains a running average calculation of all U.S. launch vehicles by key user groups (commercial, DOD, and NASA) to serve as a comparison for the 95 percent performance goal. Launch of NASA-sponsored secondary payloads on commercial or DOD missions are not included in the calculation of NASA's running average of success because they do not employ the same high level of technical oversight. The DOD provided launch services for seven NASA and National Oceanic and Atmospheric Administration (NOAA) meteorological satellites on DOD's converted intercontinental ballistic missiles from 1987 to the present; all were successful. These missions are included in the DOD running average because they provided the primary technical management for the missions.

Over this same period, NASA has used commercial ELVs for seven missions that were either secondary payloads or on-orbit service purchases. Five of these missions were successfully launched; two missions were not (the first flight of the Conestoga vehicle in 1995 with the Meteor payload and the Quick Total Ozone Mapping Spectrometer (QuikTOMS) payload in 2001 flown as a secondary payload). The running average success for these seven missions was 71.4 percent. These missions are included in the commercial launch (licensed by the FAA) running average of 90.5 percent (105 successful launches, 116 total launches). Note that we can only roughly compare these running averages because, unlike our primary payload ELV missions, both the level of technical oversight and the criteria for success vary from launch to launch for commercial and DOD ELVs.

Data Quality. The data accurately reflect NASA launch history.

Data Sources. The flight history of NASA payloads discussed in this assessment is available at https://extranet.hq.nasa.gov/elv/IMAGES/lh.pdf.

Annual Performance Goal Trends for Human Exploration and Development of Space

Annual Performance Goal	Performance Assessment			
	FY 1999	FY 2000	FY 2001	FY 2002
Strategic Goal 1. Explore the Space Frontier.				
Objective 3. Enable human exploration through collaborative robotic missions.				
2H3				●
Strategic Goal 2. Enable Humans to Live and Work Permanently in Space.				
Objective 1. Provide and make use of safe, affordable, and improved access to space.				
2H6	●	●	●	●
2H7		●	●	●
2H8				●
2H9	●	■ ↓	▲ ↑	● ↑
Objective 2. Operate the Station to advance science, exploration, engineering, and commerce.				
2H10		▲	● ↑	●
2H11			●	●
2H12			●	●
Objective 3. Meet sustained space operations needs while reducing costs.				
2H15	●	●	●	●
2H16	◆	◆	◆	◆
2H19			■	▲ ↑
Strategic Goal 3. Enable the Commercial Development of Space.				
Objective 1. Improve the accessibility of space to meet the needs of commercial research and development.				
2H17				●
2H18				●
Objective 2. Foster commercial endeavors with the Station and other assets.				
Objective 3. Develop new capabilities for human spaceflight and commercial applications through partnerships with the private sector.				
2H26				●
2H21				●
Strategic Goal 4. Share the Experience and Benefits of Discovery.				
Objective 1. Provide significantly more value to significantly more people through exploration and space development efforts.				
2H24				▲
Objective 2. Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.				
2H28				●

The NASA policy document that sets forth NASA's technical oversight approach for launch services is available from http://nodis3.gsfc.nasa.gov/library/displayDir.cfm?Internal_ID=N_PD_8610_023A_& page_name=main.

Strategic Goal 2. Enable humans to live and work permanently in space

Strategic Objective 1. Provide and make use of safe, affordable, and improved access to space

Annual Performance Goal 2H6. Assure public, flight crew, and workforce safety for all Shuttle operations.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results section of Part I.

Annual Performance Goal 2H7. Safely meet the FY 2002 manifest and flight rate commitment.

In flight for more than 20 years, the Shuttle remains the world's only spacecraft capable of satellite deployment, maintenance, repair, and retrieval; International Space Station assembly and support; and on-orbit research. The number of planned flights for FY 2002 was seven. However, because of safety concerns about the orbiter's

main propulsion flow liners, we delayed three flights. During inspection of OV-104 (Space Shuttle Atlantis) propulsion system hardware, inspectors found cracks in the fuel flow liner. The Program Inspection Team was committed to making sure the vehicle was safe even if it meant significant delays. A multicenter team gathered to find a repair option and get the orbiters flying again. The delay in meeting our flight goals is regrettable, but our emphasis on safety is correct. The FY 2002 performance proved that our safety system is sound. Overall, the mission success trend remains good. The Space Shuttle Program safely supported operating time for secondaries, expendable launch vehicles, docking and undocking with the Station, and the capture and redeployment of the Hubble Space Telescope. We achieved a rating of green for this performance goal.

Indicator 1. Achieve 100 percent on-orbit mission success for all flights in FY 2002. For this metric, mission success criteria are those provided to the prime contractor Space Flight Operations Contract for purposes of determining successful accomplishment of the performance incentive fees in the contract

Results. All four missions achieved all of their objectives. STS-108 (Space Shuttle Endeavor) carried the Expedition 4 crew and logistics to the Station in December 2001. This mission also honored the victims of the September 11, 2001, terrorist attacks by the "Flags for Heroes and Families" campaign, carrying thousands of U.S. flags into space. The flags were given to victims of the attacks or their families. STS-109, the fourth mission to service the Hubble, extended the life-expectancy and capabilities of the famous orbiting telescope. STS-110, the 13th U.S. mission to the Station, carried the first major external truss section for the Station. On June 5, 2002, we launched STS-111, which carried to the Station the fifth resident crew and the Leonardo logistics module filled with experiments.

Data Quality. Mission success data accurately reflect performance and achievements in FY 2002.

Data Sources. The Space Shuttle Customer and Flight Integration Office conducts customer surveys and converts them to mission success metrics. The office keeps the metrics for each flight.

Annual Performance Goal 2H8. Maintain a 12-month manifest preparation time.

The 12-month manifest preparation template is a standard work template we created to identify the recurring integration efforts for a nominal (that is, normal and successful) Shuttle mission. All four Shuttle launches in FY 2002 used the template. Its use is beneficial because it provides customers with an easy to grasp series of tasks needed to integrate and launch a Shuttle mission. For this annual performance goal, we earned a rating of green.

Indicator 1. Baselined Flight Requirements Document (FRD) tracks achievement of this goal and it defines the primary cargo manifest that uses the 12-month template

Results. There were four Shuttle missions in FY 2002. All missions used the 12-month template. Delays that occur after the signed flight requirements document date occur because of events such as unplanned but necessary safety modifications, payload readiness and test schedule changes, and changes in flight dates.

Data Quality. Performance data accurately reflect achievements in FY 2002. The FRD is a Space Shuttle Program controlled document. It reflects the mission's planned launch date and the schedule for key integration tasks. NASA maintains a record of all FRDs for each Shuttle mission and all changes to it.

Data Sources. The FRD is an internal Space Shuttle Program controlled document. The FRDs for the four FY 2002 Shuttle launches were as follows:

Shuttle Flight	Initial FRD Signed	Launch Planning Date at FRD Initiation
STS-108	09/26/00	10/04/01
STS-109	09/22/00	11/01/01
STS-110	12/19/00	01/17/02
STS-111	03/05/01	03/14/02

Annual Performance Goal 2H9. Have in place a Shuttle safety investment program that ensures the availability of a safe and reliable Shuttle system for Station assembly and operations.

This year's assessment is an improvement compared with previous years. We met milestones for the following safety upgrades: the advanced health management system, which will provide improved real-time monitoring of engine performance and environmental data, improved engine health advisories, better response to anomalies, and reduced risk of catastrophic engine failure; main landing gear, which will allow tire designs that are capable of higher landing speeds, allow higher cross winds and landing load limits, mitigate obsolescence issues, and improve margins for pressure leakage and colder temperatures; and cockpit avionics upgrade, which will enhance Shuttle safety by providing the crew with unprecedented situational awareness for aborts and system failures. Two other upgrades, development of external tank friction stir welding (which will improve joint strength) and industrial engineering for safety (which will reduce risks to ground personnel and flight hardware), are also proceeding on schedule. Accordingly, we earned a rating of green for this performance goal.

Indicator 1. Meet the major FY 2002 Space Shuttle Safety Upgrade milestones. For this metric, major milestones are

defined to be: the Preliminary Design Review dates, Critical Design Review dates, Ready dates for Upgrade Installation/ Integration with Flight Hardware/Software, and Ready dates for first flight

Results. This activity is essential to providing safe and reliable access to space. We accomplished all of the scheduled safety upgrade project milestone reviews for FY 2002. These include the preliminary design reviews for cockpit avionics upgrade and for the main landing gear pressure sensor.

Data Quality. The reported performance data accurately reflect achievements in FY 2002. There is also a supportability upgrade program, which is not included in this metric.

Data Sources. The Shuttle Upgrade Major Milestones Summary is available at http://sspweb.jsc.nasa.gov/upgrades/ (under the link for Upgrades Schedules). Brief descriptions of the projects are under the Upgrade Road Show link.

Strategic Objective 2. Operate the Station to advance science, exploration, engineering, and commerce

Annual Performance Goal 2H10. Demonstrate Station on-orbit vehicle operational safety, reliability, and performance.

The Station provides a safe, reliable platform for scientific research even as assembly of the Station proceeds. Our rating for this performance goal is green.

Indicator 1. Zero safety incidents (that is, no on-orbit injuries)

Results. No on-orbit safety incidents occurred, and sufficient crew time, power, and telemetry were available to complete all scheduled research.

Our careful monitoring of critical systems and operations and our attention to safety and mishap prevention has helped us complete the mission objectives.

Data Quality. The data report provided by NASA's Office of Safety and Mission Assurance accurately reflects the safety and reliability performance of the Space Station Program in FY 2002. There were no data limitations.

Data Sources. The Safety and Mission Assurance on-orbit assessment metric is located at http://iss-www.jsc.nasa.gov/ss/issapt/pmo/gprametrics.htm; however, this URL is accessible only if you have access to NASA servers. NASA is developing a new NASA management information system that will provide stakeholders access to key performance metrics and will complete it within the next performance period.

Indicator 2. Actual resources available to the payloads measured against the planned payload allocation for power, crew time, and telemetry (green = 80 percent or greater)

Results. In this performance period, the planned payload allocation for power and telemetry was available 80 percent of the time. In addition, crew time was sufficient to accomplish all planned research objectives. The total research crew time (for three increment Station crews) in FY 2002 was 920 hours. To date, we have performed 61 U.S. research investigations. The total accumulated United States and Russian research crew time is 1,497 hours.

Data Quality. The performance data accurately reflect achievements in FY 2002. The data represent the power margins and telemetry available for use at the end of each flight. The crew time metrics reflect the research hours performed by the crews (increments 3, 4, and 5). Because crew time is calculated by increments rather than by fiscal year, the hours are approximations. We base research objectives on the number of middeck lockers, up mass, and the 20-hour-per-week available crew time; the objectives are determined before each increment launch.

Data Sources. The Station research accommodations status is located at http://iss-www.jsc.nasa.gov/ss/issapt/pmo/gprametrics.htm; however, this URL is accessible only if you have access to NASA servers. A new management information system will provide stakeholders access to key performance metrics in FY 2003.

Annual Performance Goal 2H11. Demonstrate Space Station Program progress and readiness at a level sufficient to show adequate readiness in the assembly schedule.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results section of Part I.

Annual Performance Goal 2H12. Successfully complete 90 percent of the Station planned mission objectives.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results section of Part I.

Strategic Objective 3. Meet sustained space operations needs while reducing costs

Annual Performance Goal 2H15. The Space Communications Program will conduct tasks that enable commercialization and will minimize investment in government infrastructure for which commercial alternatives are being developed.

This year's assessment of green demonstrates an increase in the use of commercial data services, continuing the trend of previous years.

Indicator 1. Increase the percentage of the Space Operations budget allocated to the acquisition of commu-

nications and data services from the commercial sector from 15 percent in FY 2001 to 20 percent in FY 2002

Results. Based upon review of contract reports and the original intent of this metric, the Space Communications Program used 20 percent of its Consolidated Space Operations Contract budget for commercial services. We increased our use of commercial ground stations and video and teleconferencing services. The achievement of this goal will lead to further performance improvements in the future.

Data Quality. The results accurately reflect the performance in FY 2002.

Data Sources. Data were obtained from Center budget documents and from Space Operations Management Office commercialization plan measurements.

Annual Performance Goal 2H16. Performance metrics for each mission will be consistent with detailed program and project operations requirements in project Service Level Agreements.

This year's data delivery record was above the 95-percent-of-plan goal of the indicator. We achieved a rating of blue and continued the trend of previous years.

Indicator 1. Achieve at least 95 percent of planned data delivery for space flight missions

Results. The Space Communications Program delivered greater than 98 percent of planned data delivery.

Data Quality. The results accurately reflect the performance in FY 2002.

Data Sources. The data were obtained from the monthly program management reviews, including operations metrics reports for space science, Earth science, and human spaceflight facilities.

Annual Performance Goal 2H19. Develop and execute a management plan and open future Station hardware and service procurements to innovation and cost-saving ideas.

Indicator 1. Implement management plan—The International Space Station Program Management Action Plan (PMAP) addresses the cost and management challenges/risks in OMB, GAO, and OIG reports. It contains reforms that strengthen Headquarters involvement, increases communications, provides more accurate assessment and maintains budget accountability

Results. The Station's assembly element hardware is on schedule. Task agreements to provide the Space Station Program Manager with more direct control of all Space Station Program staff support are in place. The new Deputy Associate Administrator, who oversees both the Space Station and Space Shuttle Programs, has established more management controls. The Space Station Program plans to consolidate 28 directly managed contracts into 6, with earned value reporting as a contract requirement. Five of the seven contracts are competitive procurements that align with the President's Management Agenda. We have reworked research priorities for the budget submission. Two independent cost estimation organizations have estimated and validated the Space Station Program baseline cost. The validated cost estimates from the two studies are within 10 percent of the Space Station Program baseline cost in most years. We have established a coordination process with our international partners to discuss and agree upon options to meet utilization and research requirements. The Space Station Program has found operational cost savings to address a cost disconnect reflected in the President's FY 2002 Budget.

In this fiscal year, NASA began using a new management strategy to achieve high priority Space Station Program objectives within the funding limitations. Despite this positive step, it is still clear that we must demonstrate to the Administration and to Congress that we can complete our missions within budget. Until this is accomplished, our overall assessment rating is yellow.

Data Quality. The data accurately reflect changes and progress made in FY 2002. Progress in correcting past management deficiencies is monitored by the NASA Internal Control Council chaired by the NASA Deputy Administrator and, in November 2002, by the Management and Cost Evaluation Task Force. NASA and the OMB are working on success criteria for restoring confidence in Space Station Program management.

Data Sources. Performance assessment data are obtained from normal reporting.

Strategic Goal 3. Enable the commercial development of space

Strategic Objective 1. Improve the accessibility of space to meet the needs of commercial research and development

Annual Performance Goal 2H17. Provide an average of five mid-deck lockers on each Shuttle mission to the Station for research.

NASA exceeded the commitment to fly an average of five middeck lockers, dedicated to science, aboard each Shuttle mission to the Station in FY 2002. We achieved a rating of green. Because this is the first year for this performance goal, trend data are not available.

Indicator 1. Demonstrate that an average of five mid-deck lockers was used to support research on Shuttle mission going to the Station (source Station manifest)

Results. In FY 2002, the Space Station Program provided the science community with nine mid-deck lockers on the first utilization flight, nine mid-deck lockers on the truss delivery flight, and almost six full lockers on the second utilization flight.

Data Quality. The data report provided by the Space Station Program office accurately reflects the performance of the Space Station Program. The data pertain only to FY 2002, and align with the FY 2002 Revised Final Annual Performance Plan.

Data Sources. Performance assessment data are obtained from normal project management reporting.

Annual Performance Goal 2H18. Establish mechanisms to enable NASA access to the use of U.S. commercially developed launch systems.

NASA has five active launch service contracts. Four of these contracts include firm and option launch services, which we have exercised. The most recent contract covers a broad range of launch capabilities and includes an on-ramp opportunity allowing service providers to introduce qualified launch vehicles not available at the time of contract award. The intent of the on-ramp is to foster competition for future launch services. Each February and August during the 10-year life of this contract, NASA accepts proposals for new launch service capabilities. We achieved a rating of green for this performance goal.

Indicator 1. NASA launch service contracts in place or planned with annual on-ramps for newly developed commercial launch services as they meet NASA's risk mitigation policy

Results. We received no on-ramp proposals in February and only one proposal in August. We are evaluating the proposal received in August.

Data Quality. The performance data reported accurately reflect achievements in FY 2002.

Data Sources. The performance data were obtained from normal program reporting and from procurement documents. For more information about the NASA Launch Services contract request for proposal, including the on-ramp provisions, see http://www.ksc.nasa.gov/procurement/nls/index.html.

We post notices to the public of the upcoming open season for on-ramps on the NASA Acquisition Internet Service Web site a month before each February and August open season. See http://prod.nais.nasa.gov/cgi-bin/nais/index.cgi.

Strategic Objective 2. Foster commercial endeavors with the Station and other assets

Strategic Objective 3. Develop new capabilities for human space flight and commercial applications through partnerships with the private sector

Annual Performance Goal 2H26. Increase collaboration in space commerce with a variety of industry, academia, and non-profit organizations.

This is the first year for this metric. The FY 2002 performance indicator was achieved because of new collaborations that advance our exploration, research, and outreach efforts. Our rating for this performance goal is green.

Indicator 1. Materially participate in the development and issuance of a NASA-wide enhanced space commerce strategy document; and produce formal documents that demonstrate serious potential collaboration with at least three private sector companies

Results. In FY 2002, we participated materially in the development of the new NASA mission and vision statements and the implementation of the President's Management Agenda. We tailored our efforts to enable the commercial development of space to further the overall NASA mission and vision and the President's Management Agenda. Examples are described earlier in this report, including efforts to enhance the use of commercial launch services (annual performance goal 2H18) and our evaluation of options for Shuttle privatization (annual performance goal 2H21). Along with those activities, we developed formal collaborations with private companies. One collaboration involves the development of flexible and inflatable technologies that will enhance future human exploration; another, a commercial research experiment on the Station; and a third collaboration will enhance our education and outreach efforts.

Data Quality. Data quality information for annual performance goals 2H18 and 2H21 are described in those sections. Information about collaborations is derived from Space Act Agreements and Memoranda of Understanding with private sector companies.

Data Sources. The performance data were obtained from normal program reporting and from procurement documents. For more information about NASA's commercial development of space activities, see http://www.commercial.nasa.gov/.

Annual Performance Goal 2H21. Continue implementation of planned and new Shuttle privatization efforts and further efforts to safely and effectively transfer civil service positions and responsibilities to private industry.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results section of Part I.

Strategic Goal 4. Share the experience and benefits of discovery

Strategic Objective 1. Provide significantly more value to significantly more people through exploration and space development efforts

Annual Performance Goal 2H24. Expand public access to Human Exploration and Development of Space (HEDS) missions information (especially the Station) by working with industry to create media projects and public engagement initiatives that allow first-hand public participation using telepresence for current missions, and

virtual reality or mock-ups for future missions beyond Earth orbit.

We provided considerable public access to mission information (especially the Station) and public participation venues using mockups, the Web, and media. Our personnel participated in various educational, commercial, and political events that provided hands-on opportunities for the public to experience and become more knowledgeable about the Station and the Destiny module. More than a half million people toured these mockups and the visitor centers at the spaceflight Centers (Johnson, Kennedy, Marshall, and Stennis). For this performance goal, we earned a rating of yellow. Because this is the first year for this performance goal, trend data are not available.

Indicator 1. Museums—Track the number of science museums and other informal education forums incorporating first-person participation with the Station

Results. Data from individual installations make clear that the NASA Headquarters and Centers are actively supporting science museum and informal education events. According to the metrics maintained by the NASA Kennedy's External Relations and Business Development Directorate, Kennedy participated in 76 informal kindergarten through grade 12 educational events. In FY 2002, the audience for these events was 64,560 people who visited science fairs, career days, National Engineers Week events, and classroom presentations. Other events supported by several Centers and NASA Headquarters include the following:

IMAX—Space Station 3-D: Thousands of movie goers experienced what it is like to travel, live, and work in space and the experience of exploration and discovery aboard the Station. More than 45 major media stations aired information on the film for 2 days in April.

National Medical Association: NASA astronauts provided information about their missions and research, including delivery of the Destiny Lab to the Station and medical research aboard the Lab. The National Medical Association is the leading organization focusing on medical science and African American health issues. Tours of a full-scale mockup of the Destiny Lab provided hands-on experience with Destiny Lab features.

Science Museums: (1) The Ogden Museum exhibit featuring the Destiny Module and Environmental Control and Life Support System racks attracted about 60,000 people, including 4,000 to 5,000 students per day. (2) The Golden State Museum exhibited mini-towers that featured mockups of future space missions. About 29,000 people attended.

Data Quality. The data accurately represent events that occurred in FY 2002.

Data Sources. The spaceflight Centers (Johnson, Kennedy, Marshall, and Stennis) provided the data.

Indicator 2. Public Web presence—Track number and duration of visits to the HEDS Web site

Results. The HEDS Web site provides public access to real-time Station mission information such as time in orbit, Station news, and living in space. It also includes other interactive activities such as a ham radio project in which dozens of orbiting astronauts used the Shuttle Amateur Radio Experiment to talk to thousands of schoolchildren and their families. They have pioneered space radio experimentation, including television, text messaging, and voice communication. Other interactive links inform the public about research projects on the Station. The curator of the HEDS Web site reported an average of 14 million hits per week in FY 2002, the approximate number of hits for FY 2002 was 728 million. The duration of each Web site was not provided because the Web site visits are not currently being tracked.

Data Quality. The FY 2002 estimate extrapolated the weekly average over a 52-week year.

Data Sources. The data provided came from the metrics provided by the HEDS Web site curator. Remaining data came directly from the Web site (http://www.spaceflight.nasa.gov/).

Strategic Objective 2. Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets

Annual Performance Goal 2H28. Initiate the development and implementation of a formal and systematic mechanism to integrate HEDS latest research knowledge into the kindergarten through grade 12 or university classroom environment.

Indicator 1. Research and develop products, services, and distance learning methodologies that facilitate the application of technology to enhance the educational process for formal and informal education and lifelong learning.

Results. In FY 2002, the human exploration and development of space effort used such technological tools as videoconferencing, the Web, satellite television, and videotape programs to engage and excite learners of all ages. Of our 53 programs surveyed at space flight Centers in FY 2002, 33 percent focus on supporting students and about 40 percent have a research and development component. Fully 25 percent of programs offer each of the following: curriculum support and development, teacher/faculty preparation and enhancement, and systemic improvement of education. Just under 20 percent of our programs incorporate educational technology as an objective to enhance the educational process for formal and informal education and lifelong learning. Some examples of these projects include:

- The NASA Distance Learning Outpost (Johnson Space Center), a distance learning method of delivering NASA educational materials to groups that are remote to NASA facilities
- The Exploration Station (Kennedy Space Center), an easily accessible facility containing a variety of educational technologies and materials, which is staffed by professional educators versed in national education standards
- Mississippi Education Involvement (Stennis Space Center), a coordinated plan of statewide efforts for educational, economic, and social success in Mississippi
- NASA Explores MSFC (Marshall Space Flight Center), an Internet-based, distance learning resource about NASA's research and technology and presented in timely, high-quality, standards-based educational materials.

Data Quality. The data represent actual education program activity that occurred during the FY 2002 performance period. This information appears in the Education Implementation Action Plan.

Data Sources. The information for this performance measure was provided by the education leads and managers at each of the spaceflight Centers and from these Web sites: http://learningoutpost.jsc.nasa.gov/index.html and http://wwwedu.ssc.nasa.gov/distance_learn/dist_learn.htm#NASA Stennis Space Center.

Aerospace Technology

Strategic Goal 1. Revolutionize Aviation—Enable the safe, environmentally friendly expansion of aviation

Strategic Objective 1. Increase Safety—Make a safe air transportation system even safer

Annual Performance Goal 2R1. Complete the interim progress assessment utilizing the technology products of the Aviation Safety Program as well as the related Aerospace Base research and technology efforts and transfer to industry an icing CD-ROM, conduct at least one demonstration of an aviation safety-related subsystem, and develop at least two-thirds of the planned models and simulations.

The results of this annual performance goal and its associated indicators are located in the Highlights of the Performance Goals and Results section of Part I.

Strategic Objective 2. Reduce Emissions—Protect local air quality and our global climate

Annual Performance Goal 2R2. NASA's research stresses engine technology to reduce the emissions of oxides of nitrogen (NOx) and carbon dioxide (CO_2). The annual performance goal is to complete sector testing of a low-NOx combustor concept capable of a 70-percent reduction in NOx from the 1996 (International Civil Aviation Organization) baseline, and demonstrate at least one additional concept for the reduction of other emittants.

NASA met this goal by assessing the results of sector testing of a low nitrogen oxides combustor and determining that this technology, with a normal program of technology maturation, will be capable of reducing nitrogen oxides emissions by 70 percent from the 1996 baseline. We also demonstrated several other concepts that promise additional reductions in nitrogen oxides and carbon dioxide emissions. We achieved a rating of green for this annual performance goal.

Indicator 1. Complete sector evaluations of a combustor capable of a 70-percent reduction in oxides of nitrogen

Results. A low-nitrogen oxides combustor concept, tested in a sector configuration (or segment of a full combustor), has demonstrated a 67-percent reduction in nitrogen oxides emissions below the 1996 International Civil Aircraft Organization standards. This is just 3 points from our goal. The combustor sector ran at temperature and pressure conditions typical of engines in commercial service today. Emissions measurements were for the landing, takeoff, and cruise conditions over which environmentally friendly commercial engines will operate in the future. The demonstration increases our confidence that the full combustor can meet the 70-percent-reduction goal.

Data Quality. Mission performance data accurately reflect achievements in FY 2002. The research data were acquired using test techniques and instruments accepted by the FAA for previous commercial engine certification programs

Data Sources. Performance assessment data are from normal management reporting and are verified and validated by program managers.

Indicator 2. Select ceramic thermal barrier coating and process

Results. Several ceramic coating materials prepared using a combination of plasma spray and physical vapor deposition underwent screening for thermal conductivity and resistance to sintering. One coating withstood temperatures 300 degrees Fahrenheit higher than typical turbine blades and 1,200 cycles (100 hot hours) at 2,480 degrees Fahrenheit surface temperature. We selected that coating system for further testing on turbine blades. By significantly increasing the temperature capability of both turbine and combustor components, this new coating will increase engine turbine efficiency and reduce emissions.

Data Quality. Mission performance data accurately reflect achievements in FY 2002. The research data were acquired using test techniques accepted by the FAA for previous commercial engine certification programs.

The research data were acquired using test techniques accepted by the FAA for previous commercial engine certification programs.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 3. Demonstrate aspirating seal technology

Results. The partnership between NASA and GE Aircraft Engines to test full-scale aspirating seal in a GE90 engine will demonstrate the improved engine performance possible with these seals. This improved performance will mean reduced fuel usage and, thus, fewer carbon dioxide emissions. However, GE Aircraft Engines delayed the certification and field tests of its engine, which caused us to delay the demonstration test of the aspirating seal.

Data Quality. Mission performance data accurately reflect achievements in FY 2002. We expect to accomplish this performance measure in FY 2003.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Annual Performance Goal Trends for Aerospace Technology

Annual Performance Goal	Performance Assessment			
	FY 1999	FY 2000	FY 2001	FY 2002
Strategic Goal 1. Revolutionize Aviation—Enable the safe, environmentally friendly expansion of aviation.				
Objective 1. Increase Safety—Make a safe air transportation system even safer.				
2R1	●	▲↓	▲	●↑
Objective 2. Reduce Emissions—Protect local air quality and our global climate.				
2R2	●	◆↑	●↓	●
Objective 3. Reduce Noise—Reduce aircraft noise to benefit airport neighbors, the aviation industry, and travelers.				
2R3	N/A	●	▲↓	●↑
Objective 4. Increase Capacity—Enable the movement of more air passengers with fewer delays.				
2R4	N/A	●	●	●
Objective 5. Increase Mobility—Enable people to travel faster and farther, anywhere, anytime.				
2R5	▲	▲	▲	●↑
Strategic Goal 2. Advance Space Transportation—Create a safe, affordable highway through the air and into space.				
Objective 1. Mission Safety—Radically improve the safety and reliability of space launch systems.				
2R6	N/A	N/A	N/A	●
Objective 2. Mission Affordability—Create an affordable highway to space.				
2R7	●	■↓	■	●↑
Objective 3. Mission Reach—Extend our reach in space with faster travel times.				
2R8		●	N/A	●
Strategic Goal 3. Pioneer Technology Innovation—Enable a revolution in aerospace systems.				
Objective 1. Engineering Innovation—Enable rapid, high-confidence, and cost efficient design of revolutionary systems.				
2R9	◆	●↓	●	●
Objective 2. Technology Innovation—Enable fundamentally new aerospace system capabilities and missions.				
2R10	●	▲↓	■↓	●↑
Strategic Goal 4. Commercialize Technology—Extend the commercial application of NASA technology for economic benefit and improved quality of life.				
Objective 1. Commercialization—Facilitate the greatest practical utilization of NASA know-how and physical assets by U.S. industry.				
2R11	●	●	●	◆↑
2R12	▲	◆↑	●↓	●
Strategic Goal 5. Space Transportation Management—Provide commercial industry with the opportunity to meet NASA's future launch needs, including human access to space, with new launch vehicles that promise to dramatically reduce cost and improve safety and reliability. (Supports all objectives under the Advance Space Transportation Goal)				
Objective 1. Utilize NASA's Space Transportation Council in combination with an External Independent Review Team to assure agency-level integration of near and far-term space transportation investments.				
2R13	N/A	N/A	N/A	●

Indicator 4. Develop an integrated component demonstration plan for collaborative tests of engine demonstrators incorporating Ultra-Efficient Engine Technologies (UEET) technologies for large and small thrust class engines

Results. We completed an integrated component demonstration plan that includes planned system studies conducted with five engine companies, describes candidate propulsion systems, and identifies high risk, high payoff technologies. The plan covers transcontinental (large thrust) and regional jets (small thrust) aircraft. The plan provides the U.S. industry and NASA an integrated, systematic process to demonstrate viable technologies for advanced turbine engine components and systems.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 5. Demonstrate durability of a 2,200 degrees Fahrenheit ceramic matrix composite combustor liner. (Increase in the budget by the U.S. Congress)

Results. NASA fabricated a set of full-scale ceramic matrix composite liners and conducted a rig test to provide data to enable a go/no-go decision to be made regarding a follow-on engine test. The objectives of this effort were to design, demonstrate the feasibility of alternate fiber architecture, and manufacture a set of full-scale liners to be used to demonstrate the cyclic durability of a silicon carbide fiber reinforced silicon carbide combustor liner in a rig test. In addition, alternate methods of manufacturing the ceramic matrix composite liners were to be investigated. Based upon the liner performance during the rig test, NASA decided to proceed onto a production engine test of the ceramic matrix composite liners, which is planned for FY2003.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 6. Assess hybrid fuel cell and liquid hydrogen fueled optimized turbofan concepts

Results. We completed two feasibility studies of hydrogen-powered aircraft. The first study considered a two-seat, fuel-cell-powered aircraft with current state-of-the-art components, and the second study considered a liquid-hydrogen-engine aircraft with current, 2009, and 2022 technology levels. Results of the first study show the feasibility of a two-seat, fuel cell-powered with a 54-nautical-mile range and a 140-pound payload. Results of the second study show that transport aircraft, optimized for use with liquid hydrogen fuel and with 2022 technologies, could have a 52-percent lower take-off gross weight, lower nitrogen oxides emissions, and no carbon dioxide emissions for the same payload and range as a conventional fueled aircraft.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

These results are first-order assessments of the feasibility, benefits, and key technology barriers for both a hybrid fuel-cell propulsion system and hydrogen fueled subsonic transport resulting in zero carbon dioxide emissions. Industry counterparts appraised the data and results and deemed them to be of sufficient fidelity to achieve the study's objective.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers. Industry sources provided state-of-the-art component information for this assessment.

Indicator 7. Demonstrate concepts for reduction in gaseous, particulate, and aerosol emissions

Results. NASA developed and demonstrated an all-metal multipoint fuel-injection concept, the lean direct injector, in partnership with Goodrich Aerospace. The injector uses small mixing and combustion zones to maximize mixing and minimize emissions. Goodrich Aerospace built the injector, and NASA tested its flame tube rig. Test conditions were limited to those comparable to full-power operation for a regional jet class engine and to about 30 percent cruise power for a large transport class engine. At landing and take-off conditions, the injector concept's nitrogen oxides emission was 80.5 percent lower than the 1996 International Civil Aircraft Organization Standard. The measured particulate and aerosol emissions were at least an order of magnitude lower than those of an operational turbine engine.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 8. Identify revolutionary aeropropulsion concepts identified and assess preliminary performance

Results. An expert team assessed more than 115 proposals for advanced aeropropulsion technology concepts and chose 53 for funding. Assessment outcomes included (1) 28 university grants for a broad range of revolutionary propulsion technologies; (2) 8 sizable awards in areas such as microengines and ultra-high-power-density motors; and (3) reinforcement, replanning, or termination of 20 NASA in-house research tasks. This assessment allowed us to optimize our investment to produce technologies capable of twice the payload and range of current aircraft, air travel with near-zero to zero emissions, or high-performance aircraft missions.

Data Quality. Mission performance data accurately reflect achievements in FY 2002. A team of NASA experts conducted this assessment. Their results were consistent with an assessment conducted by Quality Function Deployment experts from the Georgia Institute of Technology.

Data Sources. Performance assessment data were obtained obtained from normal management reporting and are verified and validated by program managers.

Strategic Objective 3. Reduce Noise—Reduce aircraft noise to benefit airport neighbors, the aviation industry, and travelers

Annual Performance Goal 2R3. NASA's research stresses reducing noise in the areas of engines, nacelles, engine-airframe integration, aircraft interiors, and flight procedures. The annual performance goal is to assess and establish the strongest candidate technologies to meet the 10-decibel reduction in community noise.

We met this annual performance goal by identifying the dominant contributors to total aircraft noise and identifying concepts that would reduce or mitigate their effect. In addition, we developed an advance physics-based noise-prediction code. We achieved a rating of green for this performance goal.

Indicator 1. Identify community noise impact reduction technology required to meet 10-year, 10-decibel Enterprise goal

Results. An aircraft-level system study identified the dominant contributors to community noise: for the airframe, the landing gear is the primary source, followed by flaps and slats; for the engine, the dominant noise sources are the jet and the fan, particularly fan noise that radiates through the aft duct. Technologies to reduce landing gear noise entail streamlining flow around gear to produce a virtual gear fairing. In addition to changes to the landing gear itself, an operational modification is the later deployment of landing gear. Promising technologies for reducing engine noise include blowing from the trailing edge of the fan, sweeping the fan blades forward, and using a splitter in the aft fan duct. These physics-based jet-noise-prediction codes will enable us to optimize noise-reducing nozzle concepts. Simulations identified operations that could reduce community noise: The continuous-descent approach and delayed landing-gear deployment holds the most promise for community noise reduction. These and other concepts will be pursued in the Quiet Aircraft Technology Program, and at the end of FY 2003 the projected component benefits will be assessed on an airplane basis.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 2. Deliver initial version of improved aircraft systems noise prediction code

Results. A new code, Advanced Vehicle Analysis Tool for Acoustics Research (AVATAR) was delivered. It has all the prediction capabilities of Aircraft Noise Prediction Program (ANOPP) and the following: Linux operating system compatible, correction for propagation of jet noise through shear layer, prediction for advanced (ultra) high-bypass ratio engines, airframe subcomponent noise prediction, and atmospheric propagation (wind and temperature) effects. The new code is more accurate and faster than the older one, and the use of the Linux operating system means more industry partners can use it.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Strategic Objective 4. Increase Capacity—Enable the movement of more air passengers with fewer delays

Annual Performance Goal 2R4. NASA's research stresses operations systems for safe, efficient air traffic management and new aircraft configurations for high productivity utilization of existing runways. The annual performance goal is to develop a decision support tool, and define concepts for future aviation systems.

We met this annual performance goal by the successfully demonstrating two decision-support tools and the identifying concepts that have the potential for safely increasing the capacity of a future National Airspace System. For this performance measure, we achieved a rating of green.

Indicator 1. Develop and evaluate interoperability of decision support tools that address arrival, surface, and departure operations

Results. We conducted a simulation of the interoperability of two new graphical traffic automation tools, the Surface Management System and Traffic Management Advisor, in an environment simulating the Dallas Fort Worth Airport. Tower controllers from the airport, including the Traffic Management Coordinator and supervisor, controlled traffic and managed the airport runways. The tools worked well together and provided good decision support. In the simulation, runways 17R and 17C were initially for departures, and runway 17L was for arrivals. The Traffic Management Coordinator, who had to decide when to switch runway 17C from departures to arrivals, judged the predicted arrivals and departures timelines to be the most helpful in determining when to change the runway configuration. These tools provide information for managing the tradeoff between arrival and departure capacities more effectively and, so, for reducing delays at airports.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Two tower controllers from Memphis and Norfolk airports and representatives from several air carriers (FedEx, UPS, Northwest Airlines, United Airlines, and American Airlines) observed portions of the simulation and commented on it.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 2. Develop and evaluate a traffic flow management-decision-support tool for system-wide prediction of sector loading

Results. The newly developed Traffic Flow Automation System, a decision-support tool for predicting traffic loads, demonstrated its accuracy and speed. The software, running on a Unix-based computer cluster, processed all of the air traffic in the national airspace system's 20 Air Route Traffic Control Centers simultaneously. It was the first time this type of algorithm and model have been used to predict traffic flow for all air traffic in the national air system simultaneously. The tool tells controllers how much air traffic will be entering their sector of the sky more accurately than the current tool and 15 to 20 seconds faster.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 3. Complete virtual airspace system technology real-time environments definitions and preliminary design

Results. In FY 2002, we completed the preliminary design review and the system description document for the Virtual Airspace System Technology (VAST) simulation environment. The system will allow a real-time, system-wide, gate-to-gate, and human-in-the-loop simulation for evaluating air traffic management and air traffic control concepts.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 4. Identify candidate future air transportation system capacity-increasing operational concepts

Results. We evaluated 18 industry operational concepts that could increase airspace capacity and chose to fund 8 for further development. Each of the submitted concepts had to satisfy 27 required elements of the Virtual Airspace Modeling and Simulation (VAMS). With VAMS we will run trade-off analyses of air transportation systems concepts and technologies.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 5. Complete the critical design review for the blended wing body experimental vehicle

Results. This activity was terminated in FY 2002, and no work was conducted.

Data Quality. Not applicable.

Data Sources. Not applicable.

Strategic Objective 5. Increase Mobility—Enable people to travel faster and farther, anywhere, anytime

Annual Performance Goal 2R5. NASA's research stresses aircraft technologies that enable the use of existing small community and neighborhood airports, without requiring control towers, radar installations, and more land use for added runway protection zones. The annual performance goal is to baseline in partnership with the FAA, the system engineering documents for the Small Aircraft Transportation System concept.

We achieved a rating of green for this performance goal. The accomplishments this year provide the groundwork for the partnership to integrate our technologies into viable systems.

Indicator 1. Complete preparation of the baseline system engineering documents (including the operational requirements document, functional architecture, and technical requirements document) for Small Aircraft Transportation System concept and place under configuration management

Results. The Small Aircraft Transportation System (SATS) Project partners (NASA, FAA, and the National Consortium for Aviation Mobility) have baselined and placed under configuration management the following key Systems Engineering documents:

- Systems Engineering Management Plan: This document, from the SATS 01-002 Project Plan, governs the system engineering activities performed by NASA and its partners in the conduct of the SATS Project.
- Concepts of Operations: This document supports the development of 2010 concepts of operations that can accomplish the objectives of the SATS project. The goal of the 5-year project is to take the first steps toward the long-term SATS vision by developing key airborne technologies to provide an integrated technology evaluation and validation.
- Functional Architecture: The SATS system architecture is composed of the functional architecture and the physical architecture. These architectures are matrixed to provide the framework by which functions can be allocated to physical entities of SATS.
- Operational and Technical Requirements Document: This document defines the structure, decomposition, attributes, and management approach to SATS Project requirements. It includes reports from the requirements database of all operational (Level 1 and 2) and

technical (Level 3 and below) requirements of the SATS Project.

- Master Schedule: This document shows the project's milestones and a rolled-up time phase presentation of the activities required to complete the project.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 2. Complete preliminary design of extremely slow takeoff and landing vehicle

Results. This activity was terminated in FY 2002, and no work was conducted.

Data Quality. Not applicable.

Data Sources. Not applicable.

Strategic Goal 2. Advance Space Transportation—Create a safe, affordable highway through the air and into space

Strategic Objective 1. Mission Safety—Radically improve the safety and reliability of space launch systems

Annual Performance Goal 2R6. NASA's investments emphasize thorough mission needs development, requirements definition, and risk-reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk-reduction and architecture reviews to support design and demonstration decisions.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results section of Part I.

Strategic Objective 2. Mission Affordability—Create an affordable highway to space

Annual Performance Goal 2R7. NASA's investments emphasize thorough mission needs development, requirements definition, and risk-reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk-reduction and architecture reviews and initial hardware demonstrations to support design and demonstration decisions.

The results of this annual performance goal and its associated indicators are located in the Highlights of Performance Goals and Results section of Part I.

Strategic Objective 3. Mission Reach—Extend our reach in space with faster travel times

Annual Performance Goal 2R8. NASA's long-term research emphasizes innovative propulsions systems. The annual performance goal is to conduct a test of an advanced ion propulsion engine.

We earned a rating of green for this performance goal by successfully testing a high-power ion engine.

Indicator 1. Demonstrate >10 kilowatt operation of a 75-centimeter ion engine

Results. Research engineers demonstrated a 10-kilowatt ion engine designed for use in a nuclear electric propulsion system. Such an engine with its nearly constant propulsion could greatly reduce trip times for interplanetary missions. The high-power ion engine with titanium optics had four times the power of and a 62 percent greater specific impulse (a measure of rocket propulsion efficiency akin to miles per gallon) than the state-of-the-art ion engine. The high-power ion engine is 76 centimeters in diameter, and for this test, had 50-centimeter titanium optics.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers. For more information about ion propulsion research, see http://www.grc.nasa.gov/ WWW/Ion/.

Srategic Goal 3. Pioneer Technology Innovation—Enable a revolution in aerospace systems

Strategic Objective 1. Engineering Innovation—Enable rapid, high confidence, and cost-efficient design of revolutionary systems

Annual Performance Goal 2R9. NASA's investments emphasize advances in experimental vehicles, flight test beds, and computing tools to enable revolutionary designs. The annual performance goal is to conduct at least five demonstrations of revolutionary aerospace subsystems.

In FY 2002, there were 15 indicators to measure progress toward the engineering innovation strategic objective. Fourteen indicators were met during the fiscal year. One indicator was not fully accomplished, but is projected to be met in FY 2003. One indicator to improve the productivity of aerospace test environments will not be accomplished because work in that area was stopped. The overall assessment for this performance goal is green. This continues the good performance of the past 3 years.

Indicator 1. Develop prototype environments that are distributed across heterogeneous platforms, are dynamically extensible, and which support collaborative visualization, analysis, and computational steering

Results. We created a grid environment that provides consistent access to heterogeneous computing platforms operated with a common policy. Seventeen platforms in seven locations composed the grid, but the grid can include more platforms. Grid-based job launcher and run manager software packages automatically launched, executed, monitored, restarted, terminated, entered into a database, and analyzed 1,000 Cart3D Euler Code runs and 100 Overflow Navier-Stokes runs within 1 week for a liquid-fueled glide-back booster configuration. Users shared access to the AeroDB framework that provided the analysis, automated job management, and visualization of results. Testing and data analysis using used 13 systems at 4 locations. After 7 days, 2,863 Cart3D and 211 Overflow cases were completed. No special permissions or job queues were used. This is over three times faster than current state-of-the-art capabilities.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 2. Demonstrate improvement in time-to-solution for aerospace applications through high-end computing and end-to-end networking capabilities

Results. Grid-based job launcher and run manager software packages were developed to automatically launch, execute, monitor, restart, terminate, enter into a database, and analyze 1,000 Cart3D Euler Code runs and 100 Overflow Navier-Stokes runs within 1 week for a liquid-fueled glide-back booster configuration. The software enables designers of Space Launch Initiative vehicles to generate, rapidly and automatically, databases of conceptual designs without requiring extensive numerical simulation or the use of special expertise and skills. It also enables a large reduction in the design cycle time by integrating and automating labor intensive steps and reducing the time for database generation by a factor of three to four from current state-of-the-art capabilities.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 3. Develop capability to redesign aerospace vehicles during flight simulations exploiting high-end computing and advanced information management technologies

Results. We created a tailless version of the concept Crew Transfer Vehicle 8 within 3 days of a request and while tests on the Crew Transfer Vehicle 8 were being conducted in the vertical motion simulator. We created the aerodynamics of the modified vehicle and then modified the geometry, aerodynamic characteristics, and control system, also in response to user request. The virtual laboratory allowed pilots, researchers, and engineers to observe and analyze data in real-time and actively participate in the test design suggestions. The use of the virtual laboratory is a new approach for rapid vehicle design and specifications studies by allowing collaborative evaluation of handling qualities of vehicles while they are still on the drawing board.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 4. Demonstrate a prototype mishap-cause database of space transportation and exploration system missions including the definition of the appropriate taxonomies

Results. The prototype mishap-cause database became operational in September 2002, with core event, cause, and subsystem taxonomies that will improve risk management. The modular approach of the system allows the use of existing mishap-investigation report data (for example, from NASA and the National Transportation Safety Board). The taxonomy imposes consistent, concise, and complete classification of mishap causes. A major requirement of the taxonomy was that the classification process be reliable and repeatable and the taxonomy itself not introduce significant bias. Designers and managers may query the system for subsystem failure modes, previously identified pitfalls, safe-design best practices, and lessons learned for the mitigation of programmatic and technical risks.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

The prototype database is operational; however, its access is restricted until verification that any export control information is secured.

Indicator 5. Demonstrate a highly integrated simulation environment that facilitates the rapid development of future generation electronic devices for PetaFLOPS computing and onboard computing systems for autonomous intelligent vehicles

Results. A quantum device simulator was developed for electron transport in ultra-small and molecular devices for potential use in petaflop and low-power space computing systems. The results of the demonstration produced the following: development of formalism for full quantum

mechanical transport in a range of nanoscale devices; development of numerical methods and simulation capability to cover the range of potential nanoscale devices; implementation of simulation capability on high-performance supercomputers; demonstration of capability for ultra-small metal oxide semiconductor, field effect transistors, carbon nanotubes, and deoxyribonucleic acid (DNA) structures; journal publications and numerous conference presentations to document the developed capability; and development of scripts and other computer code enhancements for ease of use. The simulation environment will help speed the development of nanoelectronic components and systems for use in meeting the needs of the Space Science and Biological and Physical Research Enterprises.

Data Quality. Mission performance data accurately reflect achievements in FY 2002. Validation of the simulations was by peer review and journal publications.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 6. Demonstrate, in production facilities, tools and techniques for high-productivity aerospace test environment

Results. This indicator was not accomplished. Work in this area was terminated because of insufficient progress.

Data Quality. Not applicable.

Data Sources. Not applicable.

Indicator 7. Demonstrate automated software verification technology that scales to aerospace software systems

Results. The Java PathFinder model checker, with accompanying synergistic verification technologies (including, abstractions, slicing, partial-order reduction, intelligent search, and environment generation techniques) enables the efficient analysis of object-oriented, concurrent programs such as those found in the next generation of avionics systems. These model-checking technologies significantly reduce the effort required to analyze avionics software. Currently, we analyze 1,000 lines of code per day compared with 50 lines per day in 1998. The Java PathFinder model checker will also provide increased confidence and may lower the development cost of next generation avionics software.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 8. Develop system for real-time data acquisition and display of disparate instrumentation types

Results. We demonstrated a capability for simultaneous acquisition and display of real-time data from three instrument systems. The Developmental Aeronautics Revolutionizing Wind tunnels and Intelligent systems of NASA (DARWIN) is a data delivery mechanism that connects the source system and the remote customer. It captures both the structure and context of the data so that they may be retrieved and compared with other data in a manner that is intuitive and useful. Customers of NASA Ames and Langley wind tunnels will be able to use the distributed system to directly access and compare data from tests conducted at either Center.

In a separate project that also addressed this indicator, the enhancement of diagnostic software for analysis of hardware malfunctions was demonstrated. The upgraded diagnostic software in evaluating flight-like hardware and proved to be a faster, more compact diagnostic tool than previous versions (demonstrated successfully on the Deep Space–1 probe). Significant enhancements to the diagnostics include scalability, sensor noise, soft sensor failures, valve timing information, flight hardware restrictions, and ground station usability. This is enabling technology for autonomous vehicle systems that will enhance human capabilities to respond to anomalous events.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 9. Integrate and demonstrate an intelligent flight control into a C-17 simulation

Results. The integration of a neural-network-based intelligent flight-control system into a simulation of a military transport aircraft (a C-17) increases our confidence that we can flight validate, over the full altitude and speed range, a redundant flight-control system. Two NASA and one U.S. Air Force test pilot from the C-17 test force flew the simulation to ensure that neural network software flew comparable to or better than the existing C-17 control law. The pilots flew a standard set of C-17 maneuvers to determine simulation suitability. The pilots' assessments were positive. The goals of this test project are to demonstrate a control concept using a neural network to identify aircraft stability and control characteristics and to optimize aircraft performance in both normal and failure conditions. Neural-network-based flight-control technology may one day control new aerospacecraft including fighter and transport aircraft, reusable launch vehicles, uninhabited vehicles, and space vehicles.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 10. Integrate and test at least four flight experiments on the F-15B test bed aircraft

Results. Three experiments were successfully completed on the F-15B test bed aircraft. Because of a U.S. Air Force-imposed speed restriction on all F-15s, we did not test at speeds beyond Mach 1.5. In addition, a scarcity of F-15 aircraft and engine parts caused an extended downtime this year. We completed F-15B experiments for Defense Advanced Research Projects Agency (DARPA), NASA, and academia. The use of this F-15B test bed enables a more rapid transition of technology into industry, national defense, and scientific applications. We completed the following experiments:

The Johns Hopkins University Applied Physics Laboratory developed the portable neutron spectrometer for the National Space Biomedical Research Institute. This experiment validated the in-flight suitability of the portable neutron spectrometer in flight.

The flight test of the propulsion flight-test fixture showed its ability, working in combination with thee F-15B to provide a unique, low-cost flight facility for the development and flight test of advanced propulsion systems. Propulsion and flight research capabilities up to Mach 1.8 and 1,100 pounds per square foot dynamic pressure are available.

Inlet Spillage Shock Measurement flights with F-15B and F-5E experiments provided flight data for DARPA's Supersonic Shaped Boom Demonstration project. The flight test documented baseline sonic boom signature of the aircraft (near and far field) with an emphasis on inlet spillage shocks. The Quiet Supersonic Platform Program is to foster the development of new technologies sufficient to mitigate sonic boom to the point that unrestricted supersonic flight over land is possible.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 11. Demonstrate turbo-prop remotely piloted aircraft capabilities that exceed the minimum Earth Science Enterprise altitude and duration requirements

Results. The NASA Environmental Research Aircraft and Sensor Technology Program developed the Predator-B/Altair vehicle with General Atomics Aeronautical Systems, Inc., under a joint sponsored research agreement. The vehicle was selected for development to meet the requirements of the Earth Science Enterprise for an airborne science platform. The Predator-B/Altair is the next generation reconnaissance and sensor platform developed from the Predator vehicle. The events of September 11, 2001, accelerated the development and testing of the aircraft. In December 2001, the Air Force performed a Predator-B mission that demonstrated flight above 40,000 feet for greater than 24 hours and a useful payload (about 750 pounds).

The Altair is a Predator B aircraft with a 22-square-foot larger wing area and carries an additional 500 pounds of fuel. The Altair will have payload and mission duration exceeding those of the Predator-B. National security needs have delayed the completion of the Altair.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 12. Demonstrate a viscous, solution-adaptive, unstructured-grid Computational Fluid Dynamics

Results. An output-based adaptation, developed specifically to minimize the error in computed drag, provides a dramatic improvement in resolution compared with standard feature-based methods. With the output-based adaptation, the grid points are distributed in a smarter fashion; that is, they tend to cluster in the boundary layer only. This technology greatly reduces the number of grid points required for an equivalent solution accuracy, and therefore reduces (by a factor of 15) computation time. This is a unique three-dimensional error assessment capability for complex geometries. The mathematically rigorous formulation enables very efficient grids for engineering predictions with specified error levels. We accomplished this performance metric through collaboration with the Massachusetts Institute of Technology under a cooperative agreement as part of an integrated effort to produce fast, smart design and analysis methods for large-scale simulation. The effort includes a unique complex geometry/complex flow physics capability (incompressible to planetary entry physics) developed within a modern team development environment bridging the spectrum from computer-aided design to actual design.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 13. Develop conceptual high-level autonomy rover architecture

Results. Our concept for a high-level autonomy rover has the following characteristics:

- A single command cycle short traverse and instrument placement using autonomous decision-making capabilities. This architecture will be used on the K9 rover. State-of-the-art architecture (PathFinder) uses three or more command cycles for a short traverse.
- A series of long-traverse scenarios using autonomous on-board replanning for obstacle avoidance and resource (time and power) management. This architecture will be used on Rocky 8 and Rocky 9 and is a new capability.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 14. Complete a Mars mission software verification study

Results. Verification tools were applied to modules in the legacy Mars Pathfinder code and descendents of that code (Deep Space-1). On Mars Pathfinder code, latent errors were found with minimal human effort using the Polyspace Technology's software error detection tool, despite previous extensive testing. Tool-based error detection finds errors earlier in the software process and with less human effort, resulting in an order of magnitude improvement over the baseline in finding, localizing, and fixing errors. Other tools that find different kinds of errors then were applied to descendents of the Mars Pathfinder code with good results.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Detailed records of the original Mars Pathfinder verification state of practice were not available. The baseline combines generic models for aerospace software, discussions with mission personnel, and records from Deep Space-1.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 15. Complete a case study demonstrating software verification and validation techniques that are applicable to Mars mission software

Results. A study of software verification and validation techniques applicable to Mars mission software indicates that the technology advances over the last 5 years have made these tools far more usable and scalable and that their use can substantially ease verification and validation. Of particular concern to space missions are possible defects in autonomy software, such as faulty component interactions (including interactions with the environment) and defects in the execution of plans. The study also identified the gaps between current capabilities and future needs for autonomy verification. We will address these gaps through a combination of technology and algorithmic advances to enhance precision, scalability, and usability. Verification and validation researchers will work with autonomy researchers to develop tools and methodologies that scale as autonomy capabilities improve.

Data Quality. Mission performance data accurately reflect achievements in FY 2002. Four hundred hours of data were gathered on use of these advanced verification tools applied to Mars rover software. This was done through a controlled experiment simulating four teams with one using baseline tools team and the other three using separate tools. This is among the largest controlled experiments with advanced verification tools ever performed. The data quality exceeded case study requirements. However, because only eight human subjects were included in the experiment, the variations in individual capabilities in using the tools cannot be factored out. Designing the experiment to factor out individual capabilities would require an industrial-scale setup.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 16. Apply human-centered computing analysis and modeling techniques to evaluate and improve the Mars Exploration Rover (MER) 2003 flight team man-machine system performance for operations and science

Results. The MERBoard Collaborative Workspace, designed to improve mission operations for the Mars Exploration Rover, has completed two field tests. The Mars Exploration Rover team used MERBoard at its mission system thread test and its field integrated design and operations rover field test. The data gathering and use patterns will be used to improve the design.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Strategic Objective 2. Technology Innovation—Enable fundamentally new aerospace system capabilities and missions

Annual Performance Goal 2R10. NASA's investments emphasize revolutionary technologies such as nanotechnology, information technology, and biotechnology that could enable new missions and capabilities. The annual performance goal is to develop at least two new materials concepts and demonstrate the feasibility of at least two nanotechnology and two other concepts.

In FY 2002, there were 10 indicators to measure progress toward the technology innovation strategic objective. Eight of these indicators were met during the fiscal year. Two indicators were not fully accomplished, but we expect to meet them in FY 2003. The overall assessment for technology innovation is green. This is an improvement over the assessment for FY 2001, and a reversal of the trend in performance over the past 3 years.

Indicator 1. Demonstrate feasibility of nanotechnology-based chemical and biosensors and of manufacturing approaches for low-power nanoelectronic components

Results. The feasibility of nanotechnology-based sensors and electronic components was demonstrated in three areas. First, a vertically aligned carbon nanotube platform was developed to provide spatially controlled, electrically addressable arrays for electronic components and sensors. Second, nucleic acid probe molecules attached to carbon nanotube tips via covalent bonding showed an ability to amplify signals for sensing devices. Third, the electrical response of carbon nanotube field-effect transistors and indium oxide nanowire transistors to nitrogen dioxide was characterized. The nanowire transistors are a factor of 10 more sensitive than carbon nanotube transistors, and the reliability of device fabrication is much improved.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 2. Demonstrate aligned carbon nanotubes for polymer matrix material

Results. A small-scale melt extruder was designed and built to optimize alignment of carbon nanotubes. The carbon nanotubes were used to dope a low-cost, commercially available polyimide. The objective was to demonstrate the feasibility of producing aligned carbon-nanotube-doped fibers using the shear forces induced by laminar flow during extrusion. The rods were drawn to 250 micrometers in diameter to achieve approximately a 60-percent increase in the fiber tensile modulus. The drawing increased the carbon nanotubes' alignment, but it appears that there is a gradient of alignment, with alignment increasing toward the outside of the rods. Future research includes processing materials with higher carbon nanotube concentrations (5 percent) in polymer matrices. An alternative extrusion technique will also be investigated as a route toward aligned fibers. In both cases, nanocomposites will be fabricated from the processed fibers and tested.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 3. Develop and demonstrate in flight next generation neural flight control

Results. Neural-network flight-control algorithms (real-time Parameter Identification and Dynamic Cell Structure) were validated using flight hardware computers in the Boeing Phantom Works hardware-in-the-loop simulation in St. Louis, MO. The tests determined that the Dynamic Cell Structure learning neural net software would function properly in future flight tests. This testing will be used as part of the flight clearance process for an F-15 flight test. This technology has the potential to provide real-time robustness in vehicle control of unmodelled effects such as mispredicted aerodynamics or control surface failures. In addition, neural-net flight-control will reduce the number of flight-control software versions for any new vehicle, thus reducing the development cost significantly.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 4. Demonstrate oscillatory flow control actuators

Results. The effect of active oscillatory flow control on upper surface separation was evaluated during two-dimensional wind tunnel tests. A system study resulted in several recommendations for future research, such as combined leading and trailing edge excitation, higher deflection angles, and the development of a modern cruise airfoil. The system study suggestions were implemented on a wind tunnel model. The next goal is to apply this technology to a representative three-dimensional wing with a simplified high-lift system to further estimate the potential benefits. Separation control for simplified high-lift systems would enable extremely short take-off and landing vehicles. The effect of this capability is lower community noise, access to smaller airports by transport-sized aircraft, and, through potential savings in system weight, reduced fuel use (and the consequent reduced emissions).

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

The experiment is complete, and the feasibility of using oscillatory blowing for a drooped nose and simple flap on a modern airfoil was demonstrated using electrically driven zero-net mass actuators (synthetic jets). However, less than the desired amount of control was achieved. The reason appears to be that the synthetic jet actuators did not perform as well as expected. The

level of separation control achieved was consistent with the amount of actuator authority produced. Data analysis is continuing.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 5. Demonstration of space communication link technology operating at 622 megabits per second for direct space data distribution to users

Results. The 622-megabit-per-second space communications link required development of three key microwave and digital technologies: a Ka-band phased array antenna, a cryogenic receiver for the ground station, and a modem to modulate the digital data stream onto the microwave carrier frequency. Raytheon developed the electronically scannable Ka-band phased array antenna on a cost share basis. The cryogenic receiver reduces the system noise (4 decibels below conventional receivers), which allows a much smaller Ka-band ground terminal antenna. The power-efficient digital modem, based on multicarrier frequency techniques, combines four 155 megabit-per-second channels to create a wideband composite signal for very high-rate information delivery. The modem and the Ka-Band phased array are being used in a project to investigate direct data distribution from low-Earth-orbit spacecraft to distributed ground terminal sites. The low-cost, autonomous ground terminal was developed and tested at 622 megabits per second using the cryogenic receiver. The low-cost ground terminal was used in multiple demonstrations to track the Station, the Shuttle, and other low-Earth-orbit spacecraft.

Data Quality. Mission performance data accurately reflect achievements in FY 2002. Although 622-megabit-per-second data rates were achieved, synchronization of data streams remained a problem. Validation and verification of data were achieved through peer reviews of journal publications and by conducting an industry review to assure that data quality met current engineering practices and standards.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 6. Demonstrate the methodology to produce physics-based scaling laws to quantify Reynolds number sensitivities of aerodynamic flow separation on-set and progression

Results. The joint NASA and Boeing study used wind tunnel data of a 2.7 percent scale model of a Boeing 777, computational fluid dynamics data, and flight data. Analyses of the three types of aerodynamic data led to the development of new scaling laws for flow separation on-set and progression. Flow separation is an aerodynamic phenomenon that is harmful to aircraft efficiency. These new scaling laws are already in use by industry and will allow the design of more fuel efficient and therefore less polluting aircraft. The combination of wind tunnel data, flight data, and highly accurate computational fluid dynamics data represents a unique data set that has increased the capability to design more efficient and therefore less polluting aircraft.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 7. Demonstrate the ability to dynamically alter the localized flow instabilities over advanced lifting surfaces with micro-adaptive flow control devices

Results. The ability of micro-adaptive flow control devices to force attached flow on the upper surface of the wing was demonstrated in prior years during feasibility tests in Langley's Basic Aerodynamic Research Tunnel. The follow-up tests of the aircraft configuration were delayed 1 year because the aluminum propeller blades cracked during shakedown testing. New titanium propeller blades were delivered in August, and shakedown testing is scheduled for April or May 2003.

The objective of the current activity is to incorporate active separation control technology into the high-lift system on an aircraft configuration with propellers. Active separation control technology, which dynamically forces attached flow on the wing through rapidly pulsating small air jets, has the potential to enable a simpler (fewer parts), lighter weight high-lift system with equivalent or better aerodynamic performance than today's slotted flap systems. The current NASA, DARPA, and Boeing jointly funded effort is evaluating this new type of high-lift system on an extreme short takeoff and landing aircraft. The potential benefits of this technology are to reduce fuel use and emissions and to provide greater access to small airports and even unimproved fields by transport-sized aircraft.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 8. Develop concepts for design and analyses of algorithms for control of colonies of fluidic flow control effectors

Results. Modern aircraft require sophisticated flight-control systems for safe and efficient flight. Adaptive flight control systems will contribute to increased aviation safety by reducing loss-of-control accidents that

result from control surface failures (for example, jammed control surfaces, actuator failures, and uncommanded surface deflections), operation in extreme conditions, or structural damage to the aircraft. In this research, a colony of passive porosity fluidic control effectors was added to the simulated aircraft and the existing conventional control effectors. The effectiveness of the new reconfigurable controls algorithm was evaluated in computer simulations. Control effectors were systematically failed to test the ability of the reconfigurable vehicle control algorithm to identify the control's failure and to reconfigure the control authority to emphasize the Passport colony. Without reconfiguration, the aircraft became uncontrollable with a failed control effector. The simulations on the Innovative Control Effector aircraft concept illustrated the effectiveness of the new aircraft control algorithm to detect control system failure and adapt instantly for highly complex and unconventional sets of control effectors.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 9. Develop concepts for non-deterministic analyses of advanced composites, including nanotube-reinforced polymers to characterize processing uncertainties on material properties

Results. Predicting the effect of processing uncertainties in the manufacture of composite materials, including the new carbon nanotube-based composite materials, is essential to the development of accurate structural design methods. A newly developed computational method predicts the effect of manufacturing uncertainties on the strength of the composite structural material. This study is the first step in computationally determining the trade-off between manufacturing cost and the strength of nanotube-reinforced composite structures. This emerging capability will ultimately allow the design and manufacture of lighter weight and more fuel-efficient aircraft.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

The computational technique of this study is an entirely new approach for structural design based on the well-established Monte Carlo method. Laboratory validations of the method must be performed.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers. For more information, see "Nanostructured Composites: Effective Mechanical Property Determination of Nanotube Bundles," American Institute of Aeronautics and Astronautics paper 02-1523.

Indicator 10. Develop concepts for advance sensory materials development and methodologies for imbedding sensors into aerospace structural materials

Results. We developed prototype inductor piezoelectric sensors that can be embedded in structural materials and a new concept for coupling to embedded optical fiber sensors. Compared to traditional surface mounted sensors, embedded sensors offer numerous advantages. These include protection of the sensors from damage, integration of the sensors during manufacture rather than as a costly add-on, and avoidance of material surface modification.

In addition, several concepts for embedding integral vehicle health monitoring sensors into aerospace structural materials have been developed, and some preliminary tests have been performed. If successful, these concepts will enable the development of embedded sensors in future aerospace vehicles. Novel fiber-optic concept results in significant reduction in complexity and 50-percent cost reduction for embedding sensor systems into aerospace structural materials. The fiber-optic sensor concept also has the potential to benefit aircraft safety by reducing catastrophic failure of the airframe.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Strategic Goal 4: Commercialize Technology—Extend the commercial application of NASA technology for economic benefit and improved quality of life

Strategic Objective 1. Commercialization—Facilitate the greatest practical utilization of NASA know-how and physical assets by U.S. industry

Annual Performance Goal 2R11. Continue the solicitation of customer feedback on the services, facilities, and expertise provided by the Aerospace Technology Enterprise.

The annual performance goal was met by the successful completion of the customer survey. The target for customer satisfaction on the exit interviews was met. In addition, far in excess of the required number of technologies were transferred to industry in FY 2002. The overall assessment for this performance goal is blue.

Indicator 1. Achieve a facility utilization customer satisfaction rating of 95 percent at 5 or better using a

10-point scale, and 80 percent at 8 or better, based on exit interviews

Results. Three NASA Research Centers (Ames, Glenn, and Langley) conduct customer satisfaction interviews at selected wind tunnels and motion-based simulators to both gauge and improve their services to users. For the 75 surveys received in FY 2002, 92 percent of the respondents were highly satisfied (8 points or higher rating on a 10-point scale) with the service and 96 percent responded as satisfied (5 or higher rating).

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers. Satisfaction data are from facility survey surveys collected in FY 2002 for NASA's major aeronautical test facilities.

Indicator 2. Transfer at least 12 new technologies and processes to industry and other government agencies during the fiscal year

Results. In FY 2002, a significant number of NASA technology transfers were successfully accomplished. A partial listing is provided below that constitutes more than double the goal of transferring 12 technologies.

iLAB, a tool for creating high-fidelity computational parameter studies on distributed computing systems, has been transferred to Boeing Corporation. Their Phantom Works Division at Long Beach used iLAB to create and run parameter studies and to generate a matrix of computational fluid dynamics solutions to provide pretest aerodynamic estimates for upcoming wind tunnel tests in Boeing and NASA facilities. The 3 by 3 matrix of computational fluid dynamics solutions was obtained in 1 week; the computation would have taken more than 2 weeks without iLAB.

The Java PathFinder, a tool for software verification and testing, has been released to industry and university collaborators. The Java PathFinder is a verification and testing environment for Java that integrates model checking, program analysis and testing. The software is available to industry and university collaborators through a commercial technology licensing agreement.

The Performance Data Analysis and Reporting System is being used daily by 19 FAA Air Traffic Control facilities in the United States to monitor the performance of the National Airspace System, identify and analyze operational performance problems, and design and evaluate improvements to the system. The system collects, extracts, and processes air traffic control operational data.

Through a cooperative research agreement, NASA and Honeywell Commercial and Business Aircraft have been developing a data-link cockpit weather-information system called Weather INformation Network (WINN). This system provides graphic and text weather information to transport and business aircraft operating worldwide. Honeywell has chosen WINN to provide cockpit weather information for their Epic line of cockpit avionics. Honeywell recently added global winds aloft, convection and turbulence products, and a flight plan editor to WINN.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Annual Performance Goal 2R12. Continue the implementation of current education outreach plans, and establish new plans for all new program activities initiated in FY 2002.

We met the requirements of this performance goal with an overall assessment of green. The aerospace technology program offices have demonstrated their support NASA's education mission and their enthusiasm in using program resources appropriately to inspire the next generation of explorers.

Indicator 1. Implementation examples from current education outreach plans

Results. The following is a partial list of accomplishments in FY 2002:

- The Aviation Safety Program Office's Single Aircraft Accident Prevention Project is featured in a new episode of the NASA Distance Learning Program Destination Tomorrow, a news magazine format program for adult audiences. They provided subject matter, script content, and on-screen talent. Three Kid's Science News Network (KSNN) scripts are ready for production. These 1-minute vignettes that use children to explain to children in grades kindergarten to second grade mathematics, science, technology, and computer science concepts will be produced in both English and Spanish.

- The Aerospace Propulsion and Power program office produced a 21st Century Propulsion Systems video that is available on the Web and on CD.

- The Quiet Aircraft Technology Office produced two NASA KSNN newsbreaks (short commercial television broadcasts aimed at motivating elementary student interest in math and science), and one program segment (3 to 7 minutes) for NASA's Destination Tomorrow distance learning program.

- The General Aviation Programs Office worked with NASA Marshall to produce a segment for NASA Explores Web-based curriculum.

- The Ultra Efficient Engine Technology Office sponsored a "Teaching Science through Reading" workshop; filmed a "Destination Tomorrow" segment on how jet engines work; and sponsored a Young Astronaut Day with thee American Institute of Aeronautics and Astronautics.

In addition to the education activities supported directly by program and project offices, the aerospace technology mission develops and implements a wide variety of educational programs, products, and services designed to inspire academic excellence in kindergarten to 12th grade science, technology, engineering, and mathematics through the development and implementation of inquiry-based educational products that incorporate NASA aerospace technology research. Examples of these projects include:

- Virtual Skies, an interactive Web site for students in grades 9 through 12
- Exploring Aeronautics, a CD-ROM tutorial program designed for students in grades 5 through 8 about the principles of flight and aircraft design
- F-15 Active Educational Materials, a wall poster with classroom activities for grades 7 and 8 and a teacher's curriculum guide that describe this NASA research aircraft
- NASA Connect, an award-winning series of instructional television programs designed to enhance the teaching of math, science, and technology concepts in grades 5 through 8
- Destination Tomorrow, a new NASA educational program aimed primarily at adult lifelong learners
- Mobile Aeronautics Education Laboratory, a tractor-trailer unit jammed with high-tech learning stations that travels throughout the country to encourage local communities to establish teaching facilities called NASA Aerospace Education Laboratories
- Education Exhibit, an attractive and engaging educational exhibit for use at national education conferences and other appropriate educational venues
- Earth-to-Orbit Design Challenge, a program for junior high school students that challenges them to solve problems related to aeronautical and aerospace engineering, and produces curriculum materials that support the national standards for math, science, and technology education
- NASA Explores, weekly educational activities and informational updates on NASA's Aerospace Technology research and development. The site has three sections for elementary, middle, and high school students. A major theme of the Web site is the celebration of the 100th anniversary of flight
- The NASA Science Files—an educational television program designed to enhance and enrich the teaching of mathematics, science, and technology in grades 3 to 5.

Indicator 2. Documented plans for all new program activities initiated in FY 2002

Results. All new aerospace technology program activities initiated in FY 2002 produced signed, official education program plans for implementation in FY 2003. The program activities are the 21st Century Aircraft Technology Program; Advanced Space Transportation Technologies Program, Airspace Systems Program, Computing Information and Communications Technology Program, and Engineering for Complex Systems.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Strategic Goal 5. Space Transportation Management—Provide commercial industry with the opportunity to meet NASA's future launch needs, including human access to space, with new launch vehicles that promise to dramatically reduce cost and improve safety and reliability. (Supports all objectives under the Advance Space Transportation Goal)

Strategic Objective 1. Utilize NASA's Space Transportation Council in combination with an external independent review team to assure Agency-level integration of near- and far-term space transportation investments

Annual Performance Goal 2R13. Review results of NASA and commercial-sector performed launch system architecture studies, related requirements, and refinements in planned risk-reduction investments.

The annual performance goal was considered to be met because the first requirement was met by the External Requirements Assessment Team participating in the reviews and reporting their findings to NASA management. Although the Space Transportation Council was disbanded by the Agency in May 2002, numerous other teams reviewed the Space Launch Initiative Program, including the Aerospace Technology Advisory Committee, the independent review team (Independent Program Assessment Office), and an Inter-Center Analysis Team. These reviews of the Space Launch Initiative Program are equivalent to the ones that would have been provided by the Space Transportation Council. As a result, the overall assessment for this performance measure is green.

Indicator 1. Complete an assessment of the Space Launch Initiative architectures and requirements by an External Independent Review Team (EIRT); the EIRT will submit a written report on their evaluation within 45 days following completion of the review

Results. The External Requirements Assessment Team, an external independent review team of aerospace industry experts, provides senior-level advice to NASA about the Space Launch Initiative Program, and assesses requirements and analysis processes, and ensures incorporation of proven technical and programmatic methods, including the Space Shuttle legacy. The External Requirements Assessment Team is reviewing the program's Design Reference Missions and the Agency's Level 1 Requirements. The team participated in the interim architecture review and briefed the Marshall Space Flight Center Director and the Program Manager. It has also conducted and supported program reviews and provided written recommendations.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Indicator 2. The Space Transportation Council will review progress and planning of the Space Launch Initiative at least twice during the fiscal year, including the report filed by the EIRT

Results. The Space Transportation Council was disbanded by the Agency in May 2002. However, numerous other teams are actively reviewing the program, including the Aerospace Technology Advisory Committee, Independent Review Team (Independent Program Assessment Office), Inter-Center Analysis Team, External Requirements Assessment Team, OIG, and GAO.

Data Quality. Mission performance data accurately reflect achievements in FY 2002.

Data Sources. Performance assessment data were obtained from normal management reporting and are verified and validated by program managers.

Manage Strategically Crosscutting Process

NASA continually assesses the direction of the organization, adapting to changing circumstances, both external and internal. Managing strategically requires short-term and long-term appraisal of external factors facing the Agency, such as technological advances and security in the post-September 11 world. The internal factors involve determining the organizational structure that will best meet the needs of the challenges ahead. For instance, NASA assigns high priority to protecting the safety of its workforce and the environment. Other factors include integrating small- and women-owned businesses and minority universities in the NASA community, tightening financial management controls, and attracting and retaining a high-quality workforce. Management, guided by these standards of safety, quality, and efficiency, meets its performance goals and returns the taxpayers' investment.

Strategic Goal 1. Enable the Agency to carry out its responsibilities effectively, efficiently, and safely through sound management decisions and practices

Strategic Objective 1. Protect the safety of our people and facilities and the health of our workforce

Annual Performance Goal 2MS1. NASA will increase the safety of its infrastructure and the health of its workforce through facilities safety improvements, reduced environmental hazards, increased physical security, enhanced safety and health awareness, and appropriate tools and procedures for health enhancement.

NASA achieved a rating of green compared with a rating of yellow in FY 2001, blue in FY 2000, and green in FY 1999. This rating demonstrates our continued commitment to the safety and well-being of our people, property, and the national assets entrusted to us.

Indicator 1. No fatalities will result from NASA mishaps

Results. NASA had no fatalities because of mishaps.

Data Quality. The performance data reported accurately reflect the activities of FY 2002.

Data Sources. The Department of Labor's Office of Workers Compensation database for labor injury data and the NASA Incident Reporting Information System provided the basis for our performance results.

Indicator 2. Per the Federal Worker 2000 Initiative, reduce the overall occurrence of injuries (due to occupational injury or illness) by 3 percent per year from the FY 1997 baseline to 1.15 occurrences per 100 workers

Results. NASA exceeded the indicator with a case rate of 0.84 total cases per 100 workers, which is well below NASA's final goal of 1.12 in FY 2005.

Data Quality. The performance data reported are complete and accurately reflect the activities of FY 2002.

Data Sources. Our performance results originated with the Department of Labor's Office of Workers Compensation database for labor injury data and NASA personnel workforce information. Summary tables of NASA workforce data are located at http://www.hq.nasa.gov/office/codef/fm_home.html.

Indicator 3. Award construction contract(s) for all identified critical facilities safety requirements as specified in the Agency Annual Construction Program

Results. NASA awarded 92 percent of critical safety projects. The indicator was designed to help reduce safety risk and reinforce the commitment to zero-lost-time safety incidents.

Data Quality. The performance data reported are complete and accurately reflect the activities of FY 2002. Construction of Facilities managers verified the data.

Data Sources. The facilities engineering program managers gathered data for this metric. Data sources are not available to the public.

Indicator 4. Award/modify all planned contracts for physical security upgrades to NASA's minimum essential infrastructure defined in the NASA Critical Infrastructure Plan

Results. NASA completed 34 of 37 planned contracts for physical security upgrades and made other key security improvements Agency-wide as defined in the NASA Critical Infrastructure Protection Plan. Of the three contracts not awarded, one was delayed because of a GAO protest, another had technical problems that delayed bidding beyond September 30, and the third one was determined to be less hazardous than originally thought and it was downgraded in importance relative to other projects.

We will initiate more acquisition planning to minimize risk during the bid process. We will also employ preproject planning to address technical issues prior to the execution year and define project requirements that ideally will eliminate bidding problems. Finally, we will better identify and prioritize our safety projects.

Data Quality. The Centers' security chiefs considered the data accurate and complete for FY 2002.

Data Sources. The Centers' security chiefs provided the data. Some information about NASA Security Programs and security upgrades information are sensitive; therefore, they are not available to the public.

Annual Performance Goal Trends for Manage Strategically

Annual Performance Goal	Performance Assessment			
	FY 1999	FY 2000	FY 2001	FY 2002
Strategic Goal 1. Enable the Agency to carry out its responsibilities effectively, efficiently, and safely through sound management decisions and practices.				
Objective 1. Protect the safety of our people and facilities and the health of our workforce.				
2MS1	●	◆↑	▲↓	●↑
Objective 2. Achieve the most productive application of Federal acquisition policies.				
2MS2	◆	◆	◆	◆
2MS9	●	◆↑	◆	▲↓
Objective 3. Manage our fiscal and physical resources optimally.				
2MS3	■	■	●↑	▲↓
2MS10				●
Objective 4. Enhance the security, efficiency, and support provided by our information technology resources.				
2MS4	●	●	●	●
2MS5			●	●
2MS6				●
Objective 5. Invest wisely in our use of human capital, developing and drawing upon the talents of all our people.				
2MS7				●
2MS8	●	●	▲↓	■↓

Indicator 5. Reduce the level of Agency environmental noncompliance incidents and releases in order to achieve a 5-percent reduction from the FY 2000 level by 2005

Results. We far exceeded the indicator, reducing noncompliance incidents and releases by 95 percent from 218 in FY 2000 to 11 in FY 2002.

Data Quality. The performance data reported are complete and accurately reflect the activities of FY 2002.

Data Sources. The NASA Environmental Tracking System, a real-time database that stores all noncompliance incidents and releases, provided information for this indicator. The tracking system is not publicly accessible.

Indicator 6. Standardize and implement minimum elements of employee preventive and medical monitoring examinations to standardize services across the Agency using the recommendations from the U.S. Preventive Health Services Task Force

Results. NASA issued the directive "Occupational Health Program Procedures," which sets forth the minimum standards for occupational health programs. We also developed a draft statement of work for health program services that all Centers will use in future contract solicitations.

Data Quality. The Office of the Chief Health and Medical Officer (OCHMO) provided the content for the procedure and statement of work, and the office considered the information accurate and appropriate.

Data Sources. The procedures are available at http://www.nodis.hq.nasa.gov. The draft statement of work is available from the OCHMO.

Indicator 7. Establish a mechanism to aggregate employee epidemiological preventive health risk data for long-term tracking and as a basis for policy. (This action will begin the process of creating an employee longitudinal health study similar to the Astronaut Longitudinal Health Study by establishing a voluntary, statistically significant pool of employees at each Center. This pool could potentially expand the control group for the Astronaut Study and will give NASA insight into any health hazards peculiar to each Center)

Results. We established the Agency Health Enhancement Database, which records screening exams, clinic visits, employee-assistance consultations, and educational and training programs. The information provided a framework for policy decisions. In addition, we developed a two-phase feasibility study for a more comprehensive epidemiological database. The first phase was nearly complete; the second was on schedule.

Data Quality. NASA considered the OCHMO an accurate and appropriate source.

Data Sources. Because the database contains employee health information, it is not publicly accessible. The Occupational Health Program maintains a public Web site at http://ohp.nasa.gov, which discusses the types of

programs available, resources, training, related health links, employee programs, and health alerts.

Indicator 8. Develop and implement a medical quality assurance system based on a comprehensive program audits of all aspects of health care delivery and assurances of professional competency

Results. We developed a draft medical quality assurance procedure and employed the Department of Health and Human Services' electronic physician credentialing system. Bi-annual program audits and the standardized occupational health program verified the system. In addition, the OCHMO established and filled a position for a senior medical quality assurance advisor.

Data Quality. The OCHMO developed the system structure and considered it accurate and appropriate.

Data Sources. Information regarding the quality assurance system is available through the OCHMO.

Strategic Objective 2. Achieve the most productive application of Federal acquisition policies

Annual Performance Goal 2MS2. Continue to take advantage of opportunities for improved contract management by maintaining a high proportion of Performance Based Contracts (PBCs).

For Performance Based Contracting, NASA exceeded its goal of obligating 80 percent of funds available for PBC awards. These funds excluded grants, cooperative agreements, actions under $100,000, Small Business Innovation Research, Small Business Technology Transfer (STTR), federally funded research and development centers, intergovernmental agreements, and contracts with foreign governments and organizations. The overall assessment for this performance indicator is blue, continuing the trend from FY 1999.

Indicator 1. Maintaining PBC obligations at greater than 80 percent of funds available for PBCs (funds available exclude grants, cooperative agreements, actions under $100,000, Small Business Innovation Research, STTR, federally funded research and development centers, intragovernmental agreements, and contracts with foreign governments and organizations)

Results. NASA obligated 88 percent of funds available for PBC awards. The Agency has met its PBC goal for the past 5 years with percentages of 81.0 in FY 1998, and 1999, 84.0 in FY 2000, and 86.4 in FY 2001.

Data Quality. NASA examined a sampling of contracts to determine whether these met the definition of a PBC.

Data Sources. The Financial and Contractual Status System contains the Center acquisition data used for this indicator.

Annual Performance Goal 2MS9. Continue integrating small, small disadvantaged, and women-owned business together with minority universities into the competitive base from which NASA can purchase goods and services.

NASA exceeded its Congressionally mandated goal of 8 percent, awarding more than 19 percent of its total contract budget to small disadvantaged businesses. The second indicator under this annual performance goal challenged us to award 1 percent of NASA's total contract and subcontract dollars to minority educational institutions. Although we did not achieve this indicator in its first year of existence, we expect to achieve it in FY 2003 through enhanced training and outreach. Because we added this new indicator, the overall assessment for this annual performance goal is yellow compared with blue in FY 2001 and 2000 and green in FY 1999.

Indicator 1. Achieve at least an 8 percent Congressionally mandated goal for annual funding to small disadvantaged businesses (includes funding for prime and subcontractors awarded to programs supporting small disadvantaged businesses, Historically Black Colleges and Universities and other minority educational institutions, and women-owned small businesses)

Results. In FY 2002, NASA awarded more than 19 percent of its total contract budget to small disadvantaged businesses.

Data Quality. NASA's large prime contractors submitted semiannual reports on contract awards to small and small disadvantaged businesses. NASA reviewed and validated the data during our Center Procurement Management Surveys. In addition, the Small Business Administration and the DOD Contract Management Agency conducted periodic on-site surveys to verify and validate prime contractor's claims. Our Minority Business Resource Advisory Council and the NASA/Prime Contractor Roundtable also performed reviews and provided recommendations for process improvements to NASA management.

Data Sources. The NASA Acquisition Internet Service is available at http://www.procurement.nasa.gov.

Indicator 2. Award 1 percent of NASA's total contract and subcontract dollars to Historically Black Colleges and Universities and other minority institutions

Results. NASA did not achieve the indicator, although the 0.55 percent in FY 2002 represented a 10-percent improvement compared with FY 2001's percentage. NASA will conduct symposia to improve minority businesses ability to qualify for NASA contract awards.

Data Quality. Contract awards to small and small disadvantaged businesses are documented for verification and validation in the Summary Contractor Reports submitted semiannually by large prime contractors to NASA Headquarters. Headquarters personnel conduct Center

Procurement Management Surveys. In addition, the Small Business Administration and the DOD Contract Management Agency conduct periodic on-site surveys to verify and validate the performance claims and the process integrity of large prime contractor submissions. The NASA Minority Business Resource Advisory Council and the NASA/Prime Contractor Roundtable also do periodic reviews and provide NASA management with recommendations for process improvements.

Data Sources. Most of the data appears at http://procurement.nasa.gov as part of the NASA Acquisition Internet Service.

Strategic Objective 3. Manage our fiscal and physical resources optimally

Annual Performance Goal 2MS3. Revitalize Agency facilities and reduce environmental liability.

We reduced our environmental liability; however, we did not meet the facility revitalization challenge. The overall assessment for FY 2002 is yellow. In FY 1999 and FY 2000, the rating was red and in FY 2001, it was green.

Indicator 1. Improve facility revitalization rate to 100-year frequency for all facilities as identified by the integrated long-term Agency plan

Results. NASA did not achieve the performance indicator for facility revitalization. In FY 2002, the rate rose to 102 years after a steady decline from 147 years in FY 1999 to 95 years in FY 2001. The facilities revitalization rate is an industry-standard indicator of the appropriateness of the yearly amount spent to maintain facilities and is dependent on the Current Replacement Value (CRV) of NASA's facilities and the amount of annual funding. A 100-year revitalization rate indicates the minimum maintenance investment needed to ensure safe and effective operations. The industry revitalization rate averages 57 years.

The FY 2003 President's Budget funding request for facilities revitalization and NASA's CRV is expected to help us reach our goal of 100 years. Future improvements to the 100-year rate will reduce NASA's CRV through facility closures and demolition and by advocating an appropriate level of facilities revitalization funding in future budgets.

Data Quality. The performance data reported are accurate and complete for this performance period. We calculate the rate by dividing the current replacement value of the facility by the annual amount spent on its maintenance.

Data Sources. The Centers recorded the relevant data in the real property database. Facilities Engineering updated the revitalization rate to reflect appropriations and operating plan changes. The Agency's real property database is not publicly accessible.

Indicator 2. Reduce the Agency's unfunded environmental liability through a long-term strategy, annually investing an amount of not less than 3 to 5 percent of the Agency's environmental liability in environmental compliance and restoration funding

Results. NASA invested 3 percent of the Agency's environmental liability, which is estimated at $1.27 billion. The Environmental Compliance and Restoration Program obligated $38.1 million of the identified Environmental Compliance and Restoration Program projects. In FY 2003, NASA will replace the indicator with one that better measures our progress.

Data Quality. NASA maintains an internal system for recording and tracking environmental liabilities. That system has been tested and passed the FY 2002 Chief Financial Officer Act audit. The Office of the Chief Financial Officer maintains and validates the Financial and Contractual Status system.

Data Sources. The NASA internal environmental liabilities tracking system and the Financial and Contractual Status system are not accessible to the public.

Annual Performance Goal 2MS10. Improve the Agency's financial management and accountability.

NASA's commitment to the efficient and effective use of its financial resources reflects in the Agency's efforts to cost its financial resources in a timely manner and to develop an Integrated Financial Management (IFM) system. The IFM system links budget formulation, execution, accounting, and other functions for the purpose of consolidating and streamlining NASA's financial activities. We met our resources-costing goal every year since its introduction in FY 1999 (the percentage rose from 70 percent to 75 percent beginning in FY 2001). In addition, the IFM Program achieved its goals for FY 2002. The core financial module will be deployed to NASA Centers in FY 2003. The rating is green. Trend data are not available.

Indicator 1. Cost at least 75 percent of the resources authority available to cost during the fiscal year

Results. NASA costed 79 percent of its available resources in FY 2002, exceeding the indicator in this area. This indicator provided NASA with a measure of how effectively it uses its financial resources, and helped ensure that the Agency does not allow a disproportionate percentage of these resources to go unused.

Data Quality. We use data contained in our financial and contractual status reports to calculate the percentage of Agency resources costed. These reports show documentation of the Agency's costs and obligations for the fiscal year. The Office of the Chief Financial Officer compiled

the information from the Centers, Headquarters, and the Jet Propulsion Laboratory.

Data Sources. While reports are not publicly available, a resource library with links to budgets, policies, plans, and other relevant reports is located at the Office of the Chief Financial Officer's Web site at http://ifmp.nasa.gov/codeb/index.html.

Indicator 2. Initiate the pilot phase (Pilot Center cutover) of the Core Financial project and initiate at least one other module project

Results. The IFM Program completed a pilot project, initiated another module, and integrated a third.

The pilot at Marshall Space Flight Center involved the program's core financial module, designed to improve financial management. Both Glenn Research Center and Marshall completed operational readiness reviews, and no significant issues remained. In October 2003, the Centers will begin using the fourth of eight program modules.

NASA initiated the budget formulation module that encompasses bottom-up formulation of institutional-, program-, mission-, and Agency-level budget formulation requirements. The content, form, and accessibility of budget information will support real-time management decisions.

We also initiated the position description module and an integration of travel management and core financial (an expansion of the original Travel Management Project) in FY 2002. The entire financial management program is about 36 percent complete.

Data Quality. The program's financial director and the Agency Program Management Council reviewed the status quarterly. When the program initiated a new module, it submitted an addendum to the Program Commitment Agreement and a Project Scope Document.

Management reviews may consider project monthly status reports, IFM Steering Council review, Program Quarterly Status Review, Non-Advocacy Review, First Independent Annual Review, independent annual reviews, independent assessments at major project milestones, systems compliance Reviews, and requirements reviews. Independent assessment responsibilities are divided between the NASA Fairmont Independent Verification and Validation facility and an independent assessment contractor.

Data Sources. Information about the IFM Program is located at the program Web site: http://www.ifmp.nasa.gov/. The site contains information on NASA's efforts to integrate Enterprise applications, and allows visitors to remain abreast of the program. It provides background information and key deliverables, such as project plans, schedules, and strategy documents, for the entire program. This information includes data about the module projects in this program.

Strategic Objective 4. Enhance the security, efficiency, and support provided by our information technology resources

Annual Performance Goal 2MS4. Improve information technology (IT) infrastructure service delivery by providing increased capability and efficiency while maintaining a customer rating of satisfactory.

For each of the infrastructure support services, the performance of Agency-wide IT support was substantially improved in FY 2002, while customer ratings of satisfied to very satisfied were maintained. Furthermore, NASA maintained or reduced the cost-per-resource unit in each area. NASA maintained a green rating compared with the previous 3 fiscal years.

Indicator 1. Improve IT infrastructure service delivery to provide increased capability and efficiency while maintaining a customer rating of satisfactory and holding costs per resource unit to established baselines for each major IT service

Service	Established Cost Baseline
NASA ADP Consolidation Center (NACC)	$3.5 million per Processing Resource Unit
NASA Integrated Services Network (NISN)	$0.78/kilobit per second per month
Outsourcing Desktop Initiative for NASA (ODIN)	$2,940 per Standard Workstation

Results. The infrastructure support services improved in FY 2002 and maintained customer ratings of satisfied and very satisfied. In each area, NASA reduced the cost per resource unit: for NACC, to an average of $1,263,419 per processing resource per quarter for the year; for NISN, to an average of $0.49 per kilobit per second per month for the year; and for ODIN, to $2,940 per general purpose seat (GP 1, 2, and 3).

Data Quality. The Centers' Chief Information Officers, the NACC Project Office staff, the NISN Project Office staff, and the ODIN Project Office staff collect and verify the IT performance data.

Data Sources. The data sources include customer surveys and normal management reviews.

Annual Performance Goal 2MS5. Enhance IT security by meeting established performance indicators in three critical areas: vulnerabilities detected, training, and IT security plans.

A significant reduction in specified vulnerabilities, annual training of key individuals, and publication of a

complete set of IT security plans for critical systems enhanced the IT Security in FY 2002. NASA achieved a green rating in FY 2002 and FY 2001, the first year this goal was introduced.

Indicator 1. Reduce known system vulnerabilities across all NASA Centers to at least the established goal's ratios (10 percent of systems scanned, on the next page)

IT Security Element	FY 2002 Goal
Percentage vulnerabilities detected to systems scanned	10%

Results. We achieved a 12.4 percent vulnerabilities detected to systems scanned, which exceeds the FY 2002 goal of 10 percent.

Data Quality. NASA's IT security manager and the Centers' Chief Information Officers and security managers verified the results. Several layers of management review the verification process.

In the first quarter of FY 2002, we established a new base line for the phase 3 vulnerability ratio (10 percent), and during the rest of FY 2002, we scanned computer systems to determine what ratio of systems were vulnerable to the set of vulnerabilities. We measured our performance against the phase 2 vulnerability ratio. Each year we identify a new set of vulnerabilities and then scan for them.

Data Sources. Data sources include scanning systems to detect vulnerabilities, the Centers' Chief Information Officers, and IT Security Manager assessments.

Indicator 2. Provide IT security awareness training to NASA employees, managers, and system administrators at or above targeted levels (below)

IT Security Element	FY 2002 Goal
ITS Awareness Training:	
Civil Service Employees	80%
Civil Service Managers	95%
Civil Service System Administrators	90%

Results. NASA achieved the performance goal for all areas of training. We trained 98 percent of all civil service employees, exceeding the goal of 80 percent; 98 percent of all civil service managers, exceeding the 95-percent goal; and 97 percent of civil service system administrators, exceeding the 90-percent goal for that measure.

Data Quality. NASA's IT security manager and the Centers' Chief Information Officers, and training managers verified the results. Several layers of management review the verification process.

Data Sources. The training goals are measures of annual training taken. Therefore, the training measurements are reset to zero at the beginning of each year and progress toward reaching the goals is tracked throughout the year. Data sources included SOLAR Web training certification records, the Centers' Chief Information Officers, and training managers assessments.

Indicator 3. Complete 90 percent of ITS plans for critical systems, including authorization to process (below)

IT Security Element	FY 2002 Goal
IT Security Plans completed for critical systems	90%

Results. NASA completed IT plans for 100 percent of critical systems, exceeding our 90-percent indicator.

Data Quality. NASA's IT security manager and the Centers' Chief Information Officers verified the results. Several layers of management reviewed the verification process.

Data Sources. The data sources include the Centers' Chief Information Officers.

Annual Performance Goal 2MS6. Enhance mission success through seamless, community-focused electronic service delivery.

Community-focused electronic service delivery has enhanced mission success through improvements in NASA's electronic accessibility to the public. NASA continues to improve its electronic service delivery. This goal received a rating of green. There is no comparative data for previous fiscal years.

Indicator 1. Develop the eNASA Strategic Plan and Roadmap to deliver electronic services and information to the public, partners, suppliers, key stakeholders, and the internal employees and teams that execute NASA's missions

Results. The eNASA Strategic Plan and Roadmap, developed in FY 2001, formed the basis for our e-Government Plan in response to the President's Management Agenda. Our activities with respect to Expanding Electronic Government are detailed in the President's Management Agenda section of this report.

Data Quality. The performance data reported is complete and accurately reflects the activities of FY 2002.

Data Sources. The eNASA team, chartered by the NASA Office of the Chief Information Officer, produced the original eNASA Strategic Plan and Roadmap. The NASA Office of the Chief Information Officer compiled the NASA e-Government Plan in response to the President's Management Agenda requirements.

Indicator 2. Make the NASA Web more accessible, community-focused, and useful to all of NASA's diverse audiences as demonstrated by increased customer satisfaction from the FY 2001 baseline survey results

Results. NASA did not capture baseline customer satisfaction metrics in FY 2002 because of a change in plans for implementing the customer survey on the NASA homepage (http://www.nasa.gov). Rather than implement and conduct the survey, as originally planned, NASA purchased a Government survey service through the Federal Consulting Group of the Department of Treasury. Following a pilot project during part of FY 2002, the survey will be in online production in FY 2003. The data from this year will form the baseline for measuring this performance metric in subsequent years.

Offered to a random selection of visitors to the NASA homepage, the survey asks them to rate the organization, navigability, image, search capability, and other elements of the site. The survey basis is the American Customer Satisfaction Index developed by the University of Michigan. The index allows NASA to compare its customer satisfaction rating to those of other Government agencies or commercial companies.

Data from the survey will help improve the offerings of the NASA homepage and its planned replacement, the "OneNASA" Web portal. The outcome for the public will be a single Web address where students, teachers, news media, and the public can find NASA's Web offerings, fulfilling NASA's mission to inspire the next generation of explorers ". . . as only NASA can."

Data Quality. Proprietary software developed by Foresee Results of Farmington Hills, MI, collected and analyzed the data gathered in this survey. The company provides the software and analytical services through a contract with the Federal Consulting Group. The Federal Consulting Group has received OMB's approval to use this software to gather and analyze customer satisfaction data on behalf of Federal agencies.

Data Sources. The data itself is not online, although summaries appear periodically on the NASA homepage.

Indicator 3. Increase the scope and level of corporate and shared electronic services from the FY 2001 baseline

Results. NASA met this performance measure by increasing its scope and the level of its electronic services in FY 2002. Some of the new e-Government services implemented in FY 2002 include the NASA Staffing and Recruiting System (STARS), an online system (http://www.nasastars.nasa.gov) that provides information on NASA job vacancies, enables job applicants to submit resumes electronically, and provides support for NASA's human resources offices; the electronic NASA Employee Benefits Statement, which provides current pay and leave information to NASA's civil service employees; and the Gelco Travel Manager system, implemented under the IFM Program, which provides a Web-based travel management service to Agency employees.

Data Quality. The performance data completely and accurately reflect the events of FY 2002.

Data Sources. The level of corporate and shared electronic services was assessed through various activities including eNASA, the President's Management Agenda e-Government initiative, and NASA's Government Paperwork Elimination Act reporting process.

Indicator 4. Implement digital signatures that are accepted by Federal agencies for secure online communications

Results. NASA implemented digital signatures compatible with the Federal mechanism for exchanging information via the Public Key Infrastructure. An interagency panel reviewed and approved our certification process for ensuring the validity of digital signatures. We received permission to utilize the Federal Public Key Infrastructure. This approval means that NASA can send and receive secure communications with any other Federal agency that has also achieved the correct level of certification. NASA received an award for being among the first agencies to complete this process.

Data Quality. The performance data completely and accurately reflect the events of FY 2002.

Data Sources. Documentation concerning NASA's certification to use the Federal Public Key Infrastructure is located at http://www.cio.gov/fbca/news/index.htm.

Indicator 5. Post a majority of the NASA grants announcements online by the end of FY 2002, consistent with interagency efforts such as the Federal Commons Initiative which seeks to automate the Federal grants process

Results. NASA exceeded the indicator, recording 24 grant announcements this year. All of them appear online.

Data Quality. The associated data originated from interviews with representatives of the NASA grant-sponsoring organizations and through research of pertinent Web sites.

Data Sources. The grant announcements appear at the following Web sites:

- http://fedbizops.gov—the Federal Business Opportunities site, a searchable database that includes announcements from Headquarters and the Centers); and/or
- http://research.hq.nasa.gov/research.cfm—the NASA Headquarters Research Opportunities Web site, which lists research announcements associated with NASA Headquarters organizations.

Strategic Objective 5. Invest wisely in our use of human capital, developing and drawing upon the talents of all our people

Annual Performance Goal 2MS7. Align management of human resources to best achieve Agency strategic goals and objectives.

NASA aligned human resources management with Agency strategic goals by developing a comprehensive workforce planning and reporting system; enhancing Center recruitment of fresh-outs; and maintaining its supervisor-to-employee ratio. The overall assessment for this annual performance goal is green. Trend data are not available.

Indicator 1. By September 30, 2002, develop, test, and evaluate at each NASA Center a prototype of a consistent, Agency-wide workforce planning and reporting system that incorporates the current Federal Activities Inventory Reform (FAIR) Act inventory process

Results. NASA completed a prototype of workforce inventory planning in early 2002. Each Center conducted an inventory that meets the FAIR Act requirements. In May 2002, the Centers used the inventory data to improve their competitive sourcing plans. An Agency-level competitive sourcing review board evaluated the Centers' plans and used them to develop NASA's competitive sourcing plan.

We standardized our approach to defining and managing workforce competencies using the inventory. NASA formed an Agency-wide team to produce a dictionary of organizational competencies. The workforce competencies dictionary will be complete in early FY 2003. This will serve as the foundation for future competency-driven workforce planning in the Agency.

The Competency Management System team is making a link between the emerging, standard NASA competency structure and data already available in the employee database. NASA developed a new set of analysis and forecasting tools that will be available to all Centers through the Web. These tools will enable the Agency to project where competency gaps are likely to open based on attrition. NASA will be able to target recruitment and development efforts to forestall such talent gaps.

Data Quality. An independent audit firm randomly audits the NASA payroll system. Each Center independently performs a workforce survey using Agency standard formats and instructions. The result is best-available data that is not entirely accurate.

Data Sources. Data pertaining to NASA civil servants originated in the NASA Personnel/Payroll System. The NASA FAIR inventory and the competitive sourcing plan are available at http://www.competitivesourcing.nasa.gov/. Workforce analysis data and planning tools are available at http://nasapeople.nasa.gov.

Indicator 2. Develop an initiative to enhance Centers' recruitment capabilities, focusing on fresh-outs

Results. The National Recruitment Initiative focused on NASA's current and future science and engineering recruitment needs, including recent graduates. The study recommended the need for an agile, flexible hiring model that is candidate-centered, maximizes current networks, and creates new relationships to identify highly skilled candidates. The model also should market NASA's attributes as an employer of choice. We identified tools to achieve an agile, flexible hiring model.

NASA developed three Web-based recruiting tools in FY 2002.

NASA and subject matter experts developed a student-focused employment Web site located at http://www.nasajobs.nasa.gov/stud_opps/employment/index.htm. Students reviewed the site and we incorporated their recommendations into the final product.

NASA linked its NASA Jobs Web site to minority-focused and science and engineering professional association Web sites. The sites included The Black Collegian located at http://www.black-collegian.com; Women in Aviation at http://www.women-in-aviation.com/; Diversity Careers in Engineering and Technology located at http://www.diversitycareers.com/index.htm; and The Scientist's Employment Network located at http://www.scijobs.org/.

NASA developed an automatic vacancy notification feature in NASA STARS. This timesaving tool enables interested applicants to create their resumes online with NASA and to choose automatic notification of NASA vacancies. The system is available through the Applicant Services at http://www.nasajobs.nasa.gov.

Data Quality. The performance data reported are complete and accurately reflect the activities of FY 2002.

Data Sources. The performance data were collected through normal performance reporting and were validated and verified by managers.

Indicator 3. Maintain, on an Agency-wide basis (excluding the Inspector General), the supervisor-to-employee ratio of 1 to 10 within a range of +/- 0.5

Results. The Agency's supervisor-to-employee ratio remained on target. We finished the fiscal year unchanged at 1 to 10.1 with the number of supervisors declining from 1,722 to 1,711.

Data Quality. The performance data reported are complete and accurately reflect the activities of FY 2002. The NASA Personnel/Payroll System itself is an Agency system, subject to random audit. An independent audit firm audits the system for the Agency's Annual Accountability Report.

Data Sources. The performance data reported originate from the payroll system, in which current and historical records exist for each employee.

Annual Performance Goal 2MS8. Attract and retain a workforce that is representative at all levels of America's diversity.

The percent of women and minorities in the NASA workforce increased slightly over the previous fiscal year, as it has since FY 1999. In FY 1999 and FY 2000, NASA wanted to maintain workforce diversity at pre-downsizing levels. This proved an achievable goal because the majority of those leaving during downsizing were white males. For FY 2001, we agreed that NASA needed more of a stretch, and we changed the performance indicator with increased representation for women, minorities, and individuals with targeted disabilities. NASA did not meet these levels in FY 2001 or FY 2002. The overall assessment for this performance goal is red for FY 2002 compared with yellow in FY 2002 and green in both FY 2000 and FY 1999.

Indicator 1. During the fiscal year, increase representation of minorities by at least 0.6 percent, women by at least 0.4 percent, and individuals with targeted disabilities by at least 0.085 percent

Results. During FY 2002, the representation of minorities among full-time permanent employees increased by 0.4 percent, women by 0.2 percent, and individuals with disabilities by 0.04 percent. None met the levels described in the performance indicator, resulting in the red rating.

Data Quality. The NASA Consolidated Personnel and Payroll System, while not 100-percent accurate, is the most reliable and valid source available for NASA workforce data. The very small number of coding errors contained within the database would be unlikely to change the overall assessment.

Data Sources. The source of the data is the NASA Consolidated Personnel and Payroll System, which is a snapshot of the NASA workforce by pay period. Summary charts of NASA workforce data are available at http://www.naade02.msfc.nasa.gov/workforce/index.html.

Provide Aerospace Products and Capabilities Crosscutting Process

Developing cutting-edge technologies and engineering capabilities are fundamental to NASA's success. Through this process, NASA efficiently and effectively delivers systems (ground, aeronautics, and space), technologies, data, and operational services to its customers. Each year NASA improves its engineering expertise and strengthens its position as a leader in engineering research and development. We hone engineering and technological best practices and processes to improve our program and project management skills.

Strategic Goal 1. Enable NASA's Strategic Enterprises and their Centers to deliver products and services to customers more effectively and efficiently

Strategic Objective 1. Enhance program safety and mission success in the delivery of products and operational services

Annual Performance Goal 2P1. Meet schedule and cost commitments by keeping development and upgrade of major scientific facilities and capital assets within 110 percent of cost and schedule estimates, on average.

Although we again failed to meet this metric, earning a rating of yellow, we improved nearly 5 percentage points compared with last year.

Indicator 1. Development schedule and cost data are drawn from NASA budget documentation for major programs and projects to calculate the average performance measures

Results. The life-cycle cost and schedule estimates for FY 2002 are based on the FY 2004 program budget request and the program original baseline budget. The life-cycle costs for the development and upgrade of major scientific facilities and capital assets were an average of 113.7 percent of cost estimates, which is nearly 4 percentage points above the annual performance goal. The life-cycle schedules for the development and upgrade of major scientific facilities and capital assets were an average of 129.5 percent of schedule estimates, which is nearly 20 percentage points above the annual performance goal.

Our cost and schedule performance in FY 2001 was 118 percent and 123 percent, respectively, and in FY 2000 was 103 percent and 117 percent, respectively. Improvements in the FY 2002 life-cycle costs resulted from the launch of some spacecraft in FY 2001 (thus ending development costs) and the cancellation of cost-inefficient programs in FY 2002. The schedule's increase compared with FY 2001 resulted from the reduction in the total number of development programs and the large effect of the delay on the hypersonic-X program. NASA is confident that continued close attention to program management will bring improvements to both the cost and schedule estimates.

Data Quality. The performance data reported are complete and accurately reflect the activities of FY 2002. The Office of the Chief Financial Officer validated the information from cost and schedule baseline documents.

Data Sources. The Enterprises produced the cost and schedule baseline documents. The Office of the Chief Financial Officer validated the documents.

Annual Performance Goal 2P2. Track the availability of NASA's spacecraft and major ground facilities by keeping the operating time lost due to unscheduled downtime to less than 10 percent of scheduled operating time.

This metric was achieved and reflects the effectiveness of NASA's engineering capability as demonstrated by facility availability. NASA's sound engineering enables science and technology mission success. The rating for FY 2002 is blue, as it has been for the past 2 years.

Indicator 1. Each field Center reports the operational downtime of the major spacecraft and ground facilities

Results. The NASA Centers from which spacecraft and ground facilities operations take place reported the operational downtimes for the major spacecraft and ground facilities. In FY 2002, less than 1 percent of scheduled operating time was lost to unscheduled downtime. In FY 1999, 2000, and 2001, 5.6, 2.8, and 0.65 percent, respectively, of scheduled operating time were lost to unscheduled downtime, on average. The expendable launch vehicle information was not available, and the ground facility data was not fully complete at the time of this report, although no significant change is expected.

Data Quality. The performance data reported are complete and accurately reflect the activities of FY 2002.

Data Sources. The spacecraft data reported are from operational logs; ground facility data are from the NASA Facility Utilization online database.

Strategic Objective 2. Improve NASA's engineering capability to remain as a premier engineering research and development organization

Annual Performance Goal Trends for Provide Aerospace Products and Capabilities

Annual Performance Goal	Performance Assessment			
	FY 1999	FY 2000	FY 2001	FY 2002
Strategic Goal 1. Enable NASA's Strategic Enterprises and their Centers to deliver products and services to customers more effectively and efficiently.				
Objective 1. Enhance program safety and mission success in the delivery of products and operational services.				
2P1	●	■ ↓	■	▲ ↑
2P2	●	◆ ↑	◆	◆
Objective 2. Improve NASA's engineering capability to remain as a premier engineering research and development organization.				
2P3	N/A	N/A	N/A	▲
Objective 3. Capture engineering and technological best practices and process knowledge to continuously improve NASA's program/project management.				
2P4	N/A	N/A	N/A	●
2P5			▲	● ↑
Objective 4. Facilitate technology insertion and transfer, and utilize commercial partnerships in research and development to the maximum extent practicable.				
2P6	●	◆ ↑	◆	◆

Annual Performance Goal 2P3. Strengthen the NASA engineering capability through the completion of two indicators in FY 2002.

Although NASA's engineering capability is strong, we continually explore ways to improve it. The current activity will certainly make it better; however, those particular enhancements will start in FY 2003. NASA did not complete the indicators for FY 2002 and thus earned a rating of yellow. There are no trend data for this goal.

Indicator 1. Complete an assessment to identify a suitable systems engineering standard for NASA. Document the standard in the appropriate NASA system (example: NASA Procedures and Guidelines (NPG))

Results. We did not achieve this indicator in FY 2002. However, we have developed a framework for improving our engineering capability that consists of three parts:

- Develop process standards, guidelines, and requirements for systems engineering in programs and projects
- Recommend tools and methodology for comprehensive assessment of the systems engineering capability in NASA
- Evaluate the training curriculum for systems engineering offered by the Agency and provide inputs for its improvement.

In 2002, we wrote the first draft of a new policy document. We established working groups to define, evaluate, and implement the tools, assessments, and training. We also identified the resources required to develop an advanced collaborative engineering environment.

Data Quality. The results accurately reflect activities in FY 2002.

Data Sources. The Office of the Chief Engineer maintains systems engineering records.

Indicator 2. Conduct an assessment of the systems engineering capability based upon the identified systems engineering standard (NPG) to identify target areas for improvement

Results. We did not achieve this indicator because the assessment cannot be performed until the standard is complete.

Data Quality. The results are complete and reflect actual schedule status.

Data Sources. The systems engineering records are maintained in the Office of the Chief Engineer.

Strategic Objective 3. Capture engineering and technological best practices and process knowledge to continuously improve NASA's program/project management

Annual Performance Goal 2P4. Improve program and project management through the completion of two of the three indicators in FY 2002.

NASA accomplishes its mission through effective program and project management. The Agency's expectations and best practices for program and project management are published in NASA Program and Project Management Processes and Requirements (NPG 7120.5), which sets forth the procedures and guidance for implementing program and project management. To validate

the procedures, NASA benchmarks similar organizations, includes training as an integral part of the process, and continually feeds lessons learned back into the process. In FY 2002, we performed well in all areas and earned a green rating. There are no trend data for this goal.

Indicator 1. Benchmark high-tech, successful commercial companies and government organizations and apply the results to revise NASA's program/project management

Results. This indicator was achieved. The directors of the Systems Management Office and the Office of the Chief Engineer benchmarked several high-tech organizations, including Boeing's Integrated Defense Systems Program, DOD Acquisition University, Rational Software, Inc., and Lockheed Martin. The results from the benchmarking were used to improve processes at the Centers and were to validate several changes to the draft policy document (NPG 7120.5B). These benchmarking activities are ongoing.

Data Quality. The performance data are complete and accurately reflect the activities of FY 2002.

Data Sources. The Systems Management Office and the Office of the Chief Engineer collect these data.

Indicator 2. Increase the number of program and project managers completing the Advanced Program Management Training compared to the number that completed the training in FY 2001

Results. There were 79 participants in the advanced program management course in FY 2002, an increase from 38 in FY 2001. This is a new measure, introduced in the FY 2002 Revised Final Annual Performance Plan.

Data Quality. Use of two data sources and an internal functional audit of the data have provided confidence in the accuracy of the reported participation levels.

Data Sources. The Office of Human Resources and Education collects and validates training data. The logistics contractor that handles registration for all of NASA's corporate courses also maintains training records.

Indicator 3. Complete the incorporation of NASA Integrated Action Team actions into NASA policy

Results. NASA incorporated the NASA Integrated Action Team actions into policy, specifically NPG 7120.5B. We revised other policy documents and released new ones such as "Risk Management" (NPG 800.4).

Data Quality. The Office of the Chief Engineer verifies the information.

Data Sources. The NASA Integrated Action Team actions status is maintained in the Office of the Chief Engineer.

Annual Performance Goal 2P5. Capture a set of best practices/lessons learned from each program, to include at least one from each of the four Provide Aerospace Products and Capabilities (PAPAC) subprocesses, commensurate with current program status.

All Centers have well-established processes to identify best practices and lessons learned. The information is maintained, updated, made accessible, and disseminated through symposia, electronic media, biweekly newsletters, and other forms to each program or project office. Project status reviews, independent review teams, and the Agency-wide Lessons Learned Information System database also capture and disseminate lessons learned. The FY 2002 rating for this goal is green, marking an improvement from FY 2001.

Indicator 1. Lessons learned from the PAPAC subprocesses are collected and utilized in process improvement and project and program training by the Program Management Council Working Group and Code FT (Training and Development Division)

Results. This indicator was achieved. Agency programs and projects are participating by including discipline experts on the formal review teams by including lessons learned discussions in monthly project status reviews and by using independent review teams, which assess multiple programs and projects, to transfer lessons across projects. The Centers are working closely with the Academy of Program Project Leadership on case studies and project manager lessons learned forums. Many project managers have contributed their stories and lessons to the ASK magazine and project management courses. Various other lessons learned systems and processes are also very effective.

Data Quality. The performance data accurately reflect activities in FY 2002.

Data Sources. The performance assessments are based on data from normal management reporting, from the Lessons Learned Information System database and from the Academy of Program Project Leadership. For more information about the Lessons Learned Information System database and the lessons learned database, see http://llis.gsfc.nasa.gov and http://iss-www.jsc.nasa.gov/ss/issapt/lldb/, respectively.

Strategic Objective 4. Facilitate technology insertion and transfer, and utilize commercial partnerships in research and development to the maximum extent practicable

Annual Performance Goal 2P6. Dedicate 10 to 20 percent of the Agency's research and development budget to commercial partnerships.

Each year NASA has contributed significantly to commercial partnerships. These partnerships allow us to leverage both financial and human capital to further our missions. The trend is always at the top of the range for

the goal, and for FY 2002, we exceeded the goal, maintaining a blue rating for the third consecutive year.

Indicator 1. Each of the Enterprises reports contribution to commercial partnerships

Results. The percentage of NASA's research and development budget dedicated to commercial partnerships affects integrated technology planning and development with NASA partners. In FY 2002, NASA contributed 21.9 percent of its research and development investment to commercial partnerships. The FY 2002 performance exceeded the goal.

Data Quality. The performance data on which our assessment is based accurately reflect achievements of FY 2002. The Office of Aerospace Technology's Commercial Technology Division administers this metric's collection and reporting via NASA TechTracS, the Agency-wide commercial technology management information system.

Data Sources. Each Center's Commercial Technology Office collects and validates the information they enter into NASA TechTracS. NASA budget information is from the schedule and cost data of major programs and projects. For more information about NASA Commercial Technology, see http://www.nctn.hq.nasa.gov/.

Generate Knowledge Crosscutting Process

NASA provides new scientific and technological knowledge gained from exploring the Earth system, the solar system, and the universe, and gained from researching biological, chemical, and physical processes. This research is useful to scientists, engineers, technologists, natural resource managers, policymakers, educators, and the public. In generating knowledge, NASA aims to extend the boundaries of knowledge of science and engineering through high-quality research in three basic research Enterprises: Space Science, Earth Science, and Biological and Physical Research.

The generate knowledge process did not submit metrics to the FY 2002 Revised Final Annual Performance Plan. Our earlier attempts to establish metrics for this process proved unsuccessful. First, the metrics overlooked the importance of the research conducted. Second, they did not help the Agency improve a well-established process that complies with good national and international scientific practice. Finally, the NASA organization that funds the research also reports its accomplishments.

Nevertheless, we consider two metrics to be key to research programs: the percent of research funds going to peer-reviewed research proposals (a quality indicator) and the percent of NASA scientific discoveries that are considered among the "most important stories of the year" by Science News magazine (a relevance and performance indicator).

Strategic Goal 1. Extend the boundaries of knowledge of science and engineering to capture new knowledge in useful and transferable media, and to share new knowledge with customers

Strategic Objective 1. Select, fund, and conduct research programs

Annual Performance Goal. The Space Science Enterprise, the Earth Science Enterprise, and the Biological and Physical Research Enterprise will use competitive merit review wherever possible to select performers for science and basic technology research

NASA achieved a score of green for this annual performance goal. We have achieved this level of performance since FY 2000 when we began collecting the data.

Indicator 1. NASA will use Announcements of Opportunity, NASA Research Announcements, and Cooperative Agreement Notices to award 80 percent or more of science and basic research funds via merit competition in the Enterprises and functional offices that fund scientific research

Results. NASA exceeded its goal by awarding 94 percent of science and basic research funds through merit competition.

Data Quality. The performance data accurately reflect achievements in FY 2002.

Data Sources. Program budget analysts compile the performance assessment data from budget information.

Strategic Objective 2. Archive data and publish, patent, and share results

Annual Performance Goal. Research programs of the Space Science Enterprise, the Earth Science Enterprise, and Office of Life and Microgravity Sciences and Applications (currently Biological and Physical Research Enterprise/Human Exploration and Development of Space), taken together, will account for 5 percent of the "most important stories" in the annual review by Science News

We achieved a rating of green for this annual performance goal. The trend for previous years also shows remarkable performance. NASA accounted for 8.3 percent of worldwide science discoveries in calendar year 2001, the first 3 months of which were included in FY 2002, space science accounted for 6.9 percent, the Earth science for 1.2 percent, and biological and physical research for 0.2 percent. By comparison, in calendar year 2000 (FY 2001), the NASA total was 8.1 percent; for calendar year 1999 (FY 2000), 5.1 percent; and for 1998 (FY 1999), 6.5 percent.

Results. NASA accounted for 8.3 percent of worldwide scientific discoveries between January 1, 2001, and December 31, 2001. It was the best overall NASA performance for this metric since 1994, with contributions from four Centers (Goddard, Marshall, Ames, and the Jet Propulsion Laboratory) and from NASA Headquarters.

Space science accounted for 6.9 percent of discoveries—its best performance by this metric since 1996. The Hubble Space Telescope produced 1.7 percent, including the detection of the atmosphere of an extra-solar planet, a key step in construction of a planet; dust storms on Mars; a clump of stars that may be one of the first building blocks of a galaxy; and evidence that some mysterious force is pushing galaxies apart. The Chandra X-ray Observatory produced 1.3 percent of discoveries, including x-ray outburst providing further evidence of a black hole at the Milky Way core, evidence that supermassive black holes grow after host galaxies formed, and evidence of event horizons, such as the first x-ray image of Venus. Long-term environmental monitoring in the Earth science area contributed 1.2 percent of scientific discovery,

Annual Performance Goal Trends for Generate Knowledge

Annual Performance Goal	Performance Assessment			
	FY 1999	FY 2000	FY 2001	FY 2002
Strategic Goal 1. Extend the boundaries of knowledge of science and engineering to capture new knowledge in useful and transferable media, and to share new knowledge with customers				
Objective 1. Select, fund, and conduct research programs.				
2GK		●	●	●
Objective 2. Archive data and publish, patent, and share results.				
2GK	●	●	●	●

including data from the Landsat. The Geostationary Operational Environmental Satellite series of missions contributed to studies of large-scale deforestation in Central America and its effects on ecosystems and weather. Nimbus 4 data (combined with the Advanced Earth Observing Satellite) provided evidence of an increase in the greenhouse effect between 1970 and 1997. The biological and physical research effort made its first contribution (0.2 percent) to the most important stories list. A physical sciences grant funded basic physics research that brought traveling light to a full stop, held it, and then sent it on its way. Trapping and releasing light could have an important influence on the development of future information technologies.

Data Quality. Science News, a weekly periodical published since 1973, issues an annual review of what the periodical's editors consider the most important stories for the year. The quality of the data is limited by the cycle of the publication, which covers stories from January 1, 2001, to December 31, 2001, instead of FY 2002. Although the review covers what the editors consider all fields of science, it is limited by the subjective nature of choosing which highlights are most newsworthy to incorporate and by the limited space allotted for publication.

Data Sources. The source of data is the Science News edition from the week of January 7, 2002.

Communicate Knowledge Crosscutting Process

Engaging the public is essential to our goal of increasing scientific and technological knowledge. To inspire a new generation of scientists and engineers, the Agency uses a variety of public media, such as exhibits, Internet portals, interactive media, and face-to-face and remote contact with astronauts, engineers, and scientists. In support of education, we offer students and teachers the opportunity to interact with our personnel through numerous learning modules. The education program offices collaborate with school systems to develop aerospace and science curricula that will encourage and inspire. Private industry harnesses our extensive online databases to meld research data into products that raise humankind's quality of life. Moreover, NASA pays heed to the arts through its national Fine Arts Program in which world-renown artists display their interpretations of aerospace advancements.

Strategic Goal 1. Ensure that NASA's customers receive information from the Agency's efforts in a timely and useful form

Strategic Objective 1. Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable

Annual Performance Goal 2CK1. Share the experience of expanding the frontiers of air and space with the public and other stakeholders by meeting four of the five indicators for this goal.

NASA achieved this annual performance goal of sharing the experience of expanding the frontiers of air and space with the public and other stakeholders. We earned a rating of blue compared with ratings of green for the past 3 years.

Indicator 1. More Americans can visit a NASA exhibit, through a minimum of 350 events per year

Results. NASA sponsored more than 350 events featuring NASA exhibits in FY 2002. The number of interactive exhibits increased in FY 2002. In a continuing effort to create more interactive exhibits, we upgraded videotape audiovisuals to CDs. In addition, we are producing new components exclusively on DVDs.

Two Centers produced two virtual exhibits. One is called the Shuttle Launch Experience and the other one is a virtual conversation with John Glenn. NASA added an inflatable astronaut to the inventory and produced exhibits for Centennial of Flight in 2003. Each of the Centers updated graphics to keep programs current.

Data Quality. The Exhibits Program outcomes accurately reflect performance and achievements in FY 2002.

Data Sources. The data sources are monthly activity reports from our Centers.

Indicator 2. Public attendance and participation in the NASA Art Program will increase, through exhibitions in 15 additional states

Results. The NASA Fine Arts Program exceeded its 40-state goal by traveling to 44 states with its Artrain, a traveling exhibit that transports NASA's art collection to cities nationwide. Artrain has traveled to new states including Arkansas, Wyoming, Nebraska, Washington, Oregon, Nevada, Utah, and Colorado. The Artrain has broadened the Program's exposure, registering increased public attendance and participation in FY 2002. Stories in publications such as New York Magazine, the Tate Museum Magazine, Brandweek, and the Los Angeles Times, as well as network programming, such as CBS Sunday Morning, generated great interest in NASA and its art initiatives. A new exhibit that includes works from the Program was created by the U.S. Department of State and is traveling internationally to embassies.

Data Quality. The Fine Arts Program outcomes accurately reflect performance and achievements in FY 2002.

Data Sources. The data sources are monthly activity reports from our Centers.

Indicator 3. Agency officials and astronauts will convey clear information on NASA activities through the most used media in America: television, through no less than 20 live shots per month on average

Results. NASA averaged 40 live-shot interviews per month in FY 2002, 20 more than our target. The total number of live interviews completed was 400. The interview topics included how to track and view the Station, flags for heroes and families, IMAX Space Station 3-D, the Child Presence Sensor, the Viking 25th anniversary, and the art of Landsat.

Data Quality. The NASA Television Live-Shot Program outcomes accurately reflect performance and achievements in FY 2002.

Data Sources. The data sources include monthly activity reports from our Centers. NASA television producers maintain on-air records and reports.

Indicator 4. NASA's activities and achievements will be chronicled and put into perspective for the American public, through 10 new historical publications

Annual Performance Goal Trends for Communicate Knowledge

Annual Performance Goal	Performance Assessment			
	FY 1999	FY 2000	FY 2001	FY 2002
Strategic Goal 1. Ensure that NASA's customers receive information from the Agency's efforts in a timely and useful form.				
Objective 1. Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable.				
2CK1	●	●	●	◆↑
Objective 2. Disseminate scientific information generated by NASA programs to our customers.				
2CK2	●	●	●	◆↑
Objective 3. Transfer NASA technologies and innovations to private industry and the public sector.				
2CK3	●	●	●	◆↑
Objective 4. Support the Nation's education goals.				
2CK4	●	●	●	▲↓

Results. The History Office exceeded its FY 2002 indicator by issuing 11 new historical publications. In addition, other publishers reprinted three publications that originally appeared in the NASA History Series.

Data Quality. These publications are fully peer reviewed, and their quality is comparable to that of academic press publications. They are analytical and scholarly in their treatment of complex technical and historical issues.

Data Sources. The data sources include monthly activity reports from our Centers and NASA's annual History Program review.

Indicator 5. Documents significant in the Agency's history will be made available to a larger audience by producing one, new electronic document—a CD-ROM

Results. The History Office completed a CD-ROM called Shuttle-Mir: The United States and Russia Share History's Highest Stage (SP-2001-4603, December 2001). This CD-ROM includes text of a book by the same title, as well as documents, multimedia materials, oral history transcripts, and additional analysis.

Data Quality. NASA History CD-ROMs are peer reviewed to ensure high quality standards.

Data Sources. The data sources include monthly activity reports from our Centers and NASA's annual History Program review.

Strategic Objective 2. Disseminate scientific information generated by NASA programs to our customers

Annual Performance Goal 2CK2. Inform, provide status, enthuse, and explain results, relevance, and benefits of NASA's programs by meeting two of the three indicators for this goal.

For this annual performance goal, we achieved a rating of blue. Our ratings were green for the past 3 years.

Indicator 1. Effective use of the NASA homepage to communicate knowledge about NASA's scientific and technological achievements to the public. Effectiveness will be rated by placing at least 50 stories about breaking news on science and technology discoveries

Results. In FY 2002, the Office of Public Affairs continued to average more than one story posted per business day on the NASA homepage, for nearly 300 stories covering the Agency's entire program.

Data Quality. The NASA homepage outcomes accurately reflect performance and achievements in FY 2002.

Data Sources. Data sources include monthly reports from NASA Centers. Automatic statistics gathering software collects Web site and related traffic statistics. NASA Center television producers maintained on-air records and reports. Other statistics come from counters on Web pages, normal management reporting, and the annual NASA History Program review. There is some limitation to these data because Web page counters do not document why an individual accesses a Web page.

Indicator 2. The History Office will create one additional online exhibit on the NASA History Web page

Results. The History Office exceeded its performance indicator of creating one additional online exhibit on the NASA History Office Web page by creating 15 in FY 2002. Some of the online exhibits are as follows:

- Magellan: The Unveiling of Venus (JPL-400-345) http://history.nasa.gov/JPL-400-345/magellan.htm

- The Space Shuttle Decision: NASA's Search for a Reusable Space Vehicle (SP-4221) http://history.nasa.gov/SP-4221/sp4221.htm.

Data Quality. These new historical sites fall into two categories: electronic versions of previously published materials and new materials. The electronic versions of books are faithful to the original print materials, which were peer reviewed, in that they include all the text, images, and original pagination. New sites that are not versions of existing books are peer reviewed for quality before they are placed on the Web.

Data Sources. Data sources include monthly reports from Centers. Automatic statistics-gathering software collects Web site and related traffic statistics. NASA Center television producers maintain on-air records and reports. Other statistics come from counters on Web pages, normal management reporting, and the annual NASA History Program review. There is some limitation to these data because Web page counters do not document why an individual accesses a Web page.

Indicator 3. The History Office will meet the need for a timely and effective response to the public by meeting or exceeding 90 percent of the time a 15-day response standard

Results. The History Office responded to its 200-plus monthly e-mail inquiries within 7 days 95 percent of the time, exceeding our goal.

Data Quality. The NASA History Office responded using its extensive historical reference collection, consisting of more than 1,500 linear feet of key primary and secondary sources on a wide range of aerospace history topics. Numerous researchers both inside and outside of NASA have used this collection to answer with confidence many historical queries. There is some limitation to these data because Web page counters do not document why an individual accesses a Web page.

Data Sources. The data sources include monthly reports from NASA Centers. Automatic statistics-gathering software collects Web site and related traffic statistics. NASA Center television producers maintain on-air records and reports. Other statistics come from counters on Web pages, normal management reporting, and the annual NASA History Program review.

Strategic Objective 3. Transfer NASA technologies and innovations to private industry and the public sector

Annual Performance Goal 2CK3. Ensure consistent, high-quality, external communication by meeting three of the four indicators for this goal.

NASA demonstrated our ability to provide high-quality external communications by achieving all indicators for this goal. For this annual performance goal, we achieved a rating of blue and ratings of green for the past 3 years.

Indicator 1. Effectively communicate technologies available for commercial use and technologies that have been commercialized by industry, through specific publications. Effectiveness will be measured by monitoring print and electronic distribution

Results. NASA uses the Internet and educational programs to make the latest technological developments available to the public. For example, the NASA Tech Briefs Web site is available to download technical support packages, which provide in-depth information in the NASA Tech Briefs publication. NASA also uses the online edition of Aerospace Technology Innovation, the public's source for current information on NASA projects and opportunities in technology transfer and commercialization, aerospace technology development, and commercial development of space.

Data Quality. The outcomes for the commercial use of technologies accurately reflect performance and achievements in FY 2002.

Data Sources. Print and Web data are from the NASA TechTracS database, the NASA Headquarters Printing and Design Office, and the aerospace technology mission, through its support organizations.

All commercial publications (NASA Tech Briefs, Aerospace Technology Innovation, and Spinoff) are accessible online at http://www.nctn.hq.nasa.gov/.

Indicator 2. Publish at least one industry specific, special edition of Aerospace Technology Innovation issue in FY 2002, to attract new readership and encourage partnerships with targeted industry sectors

Results. NASA published two special editions of its Aerospace Technology Innovation magazine in FY 2002: "Medical Imaging: NASA's New Initiative" and "Advancing Software Technology with U.S. Industry." These special editions promoted NASA medical technologies to targeted industry groups and publicized NASA software technologies.

Data Quality. The performance data reported accurately reflect activities in FY 2002. Print and Web data were controlled by the Office of Aerospace Technology and through its support organizations.

Data Sources. Performance data are obtained through normal management communications. Aerospace Technology Innovation is available to the public in print (by free subscription) and on the Web at http://www.nctn.hq.nasa.gov.

Indicator 3. Carry out effective NASA technology transfer market outreach to the medical device industry

Results. In FY 2002, we published a Web-based database that we use to collect and assist in the managing of research collaborations and licensing

opportunities in the medical device area at http://www.nasamedical.com/. We held an event at Arizona State University promoting NASA medical and information technologies to industry. The event was attended by the medical industry from around the state. We published (in print and on the Web) an industry-specific edition of Aerospace Technology Innovation entitled "Medical Imaging: NASA's New Initiative."

Data Quality. The performance data reported accurately reflect activities in FY 2002.

Data Sources. Performance data are obtained through normal management communications.

Indicator 4. The NASA TechTracS database, accessible through the Internet, will list at least 18,000 NASA technologies that are considered to be of benefit to U.S. industry and the public

Results. In FY 2002, the NASA TechTracS online database provided 20,890 viable NASA technologies considered to be of benefit to U.S. industry and to the public. This exceeded the goal of 18,000.

Data Quality. The performance data reported accurately reflect activities in FY 2002. Data is maintained and configuration controlled by each NASA Center.

Data Sources. Data is available to the public through the Web at http://technology.nasa.gov.

Strategic Objective 4. Support the Nation's education goals

Annual Performance Goal 2CK4. Using NASA's unique resources (mission, people, and facilities) to support educational excellence for all, NASA supports the Nation's education goals by meeting three of the four indicators for this performance goal.

For this annual performance goal, the communicate knowledge process achieved a rating of yellow compared with ratings of green for the past 3 years. This yellow rating is because of incomplete data for FY 2002.

Indicator 1. Provide excellent and valuable educational programs and services, maintaining an "excellence" customer service rating ranging between 4.3 and 5.0 (on a 5.0 scale) 90 percent of the time

Results. The FY 2002 data are incomplete; however, preliminary data show that the average excellence rating is 4.63. Once the data are finalized in January 2003, the results are expected to meet or exceed the 4.3 goal.

The excellence rating is an average of the responses for the following questions on the NASA Education Program Framework and Evaluation System: rate the program staff; what kind of recommendation one would make to someone who asks about applying to the program; expectation about applying what was learned in the program; and the value of the experience.

Data Quality. The performance data presented are complete and accurately reflect progress made in FY 2002.

Data Sources. The data for the ratings are from the NASA Education Program Framework and Evaluation System.

Indicator 2. NASA will involve the educational community in its endeavors, maintaining a level of involvement of approximately 3 million participants, which include teachers, faculty, and students

Results. Preliminary data show that 2,649,831 individuals directly participated in NASA education programs in FY 2002. We expect the final data to show that we exceeded the 3 million mark.

Data Quality. Although program participation data collection ended on September 30, we are not able to include complete and verified data for this indicator. The final FY 2002 assessment will be available in the second quarter of 2003.

Data Sources. The education program offices maintain an online data collection system, which captures participant demographic information and excellence ratings for specific program features.

Indicator 3. Through meaningful partnerships, NASA will increase the amount of total funding obligation from the FY 2000 baseline for Historically Black Colleges and Universities and Other Minority Universities

Results. We accomplished this indicator. The Minority University Research and Education Program was allocated $82.1 million to manage the Historically Black Colleges and Universities Program and the Other Minority Universities Program. This amount does not include the Centers' and Enterprises' funding. Evidence of the Agency's accomplishment in these areas is shown by the 6 National Research Announcements that resulted in 60 new awards: Partnership Awards for the Integration of Research into undergraduate education—4 awards; Minority University Mathematics, Science and Technology Awards for Teacher Education Program—10 awards; Precollege Achievement of Excellence in Mathematics, Science, Engineering and Technology—12 awards; Faculty Awards for Research—23 awards; NASA Group 3 Historically Black Colleges and Universities University Research Centers—7 awards; and NASA Group 3 Other Minority Universities University Research Centers—4 awards.

Data Quality. The performance data presented are complete and accurately reflect progress made in FY 2002.

Data Sources. We obtained the performance data from budget documents.

Indicator 4. NASA will establish an undergraduate scholarship program beginning in FY 2002

Results. We will establish the undergraduate scholarship program in FY 2004, pending legislative authority for the service component and therefore, this program has not been developed in FY 2002.

Data Quality. The performance data presented are complete and accurately reflect progress made in FY 2002.

Data Sources. We obtained this data from procurement documentation.

PART III

Financial

Letter From the Deputy Chief Financial Officer

I am pleased to present NASA's first combined Performance and Accountability Report prepared in accordance with the Reports Consolidation Act of 2000. Further, NASA has received an unqualified audit opinion on NASA's FY 2002 financial statements. This is a tremendous accomplishment for the Agency considering that the FY 2001 financial statements were disclaimed.

Consistent with the Reports Consolidation Act and Office of Management and Budget guidance, NASA has met FY 2002 accelerated reporting requirements by preparing NASA's performance results 2 months earlier than last year and preparing the audited financial statements 1 month earlier than last year. NASA could not have achieved these performance goals in both the quality and timeliness of reporting without the dedication of NASA employees at Headquarters, the Centers, the Office of Inspector General, our independent public accountant, and NASA contractors.

NASA recognizes that these accelerated reporting requirements will remain the same for FY 2003 reporting, but will increase dramatically for FY 2004. NASA is working diligently with all NASA employees at Headquarters, the Centers, our contractors, and our auditors to reengineer our processes and associated internal reporting requirements and guidance to ensure NASA will meet the deadline of November 15, 2004, for issuance of the FY 2004 report.

While working diligently with our auditors, we were able to overcome our previous year's disclaimer of an audit opinion. NASA is pleased to be able to show the significant strides that we have made in FY 2002 in receiving an unqualified audit opinion for FY 2002 financial statements, which is good news for NASA. NASA acknowledges that other significant work is still needed to improve our overall financial management reporting.

NASA management has identified through the Federal Managers' Financial Integrity Act, and our auditors continue to report, the internal controls surrounding NASA's Property, Plant and Equipment and Materials as a material weakness. During FY 2003, NASA plans to improve our Property, Plant and Equipment and Materials published policy and procedures. Also, NASA will provide additional guidance to contractors on the necessary contractor-held-property reporting and increase NASA-provided training to contractors on how to prepare these reports. Further, our auditors have also identified NASA's process for preparing our Financial Statement and Performance and Accountability Report as a material weakness. NASA plans to review its Financial Statement and Performance and Accountability Report process and make significant changes to the FY 2003 preparation and reporting cycle.

Finally, NASA and its auditors have concluded that our financial management systems are not substantially compliant with Federal financial management systems requirements. During FY 2003, NASA is installing a commercial off-the-shelf core accounting system that meets Federal requirements. NASA plans to be substantially compliant at the end of FY 2003.

Overall, NASA has made significant financial management reporting improvement during FY 2002. I look forward to reporting more improvements in FY 2003.

Gwendolyn Brown

Deputy Chief Financial Officer

Financial Statements and Related Auditor's Reports

Financial Overview

SUMMARY OF FINANCIAL RESULTS, POSITION, AND CONDITION

NASA's financial statements report the Agency's financial position and results of operations. The principal financial statements are the Consolidated Balance Sheet, the Consolidated Statement of Net Cost, the Consolidated Statement of Changes in Net Position, the Combined Statement of Budgetary Resources, and the Combined Statement of Financing. Additional financial information is also presented in the required supplementary schedules.

The Chief Financial Officer's Act of 1990 requires that agencies prepare financial statements to be audited in accordance with Government Auditing Standards. While we prepared these financial statements from NASA's books and records in accordance with formats prescribed by the OMB, the statements are in addition to financial reports, prepared from the same books and records, that we use 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.

NASA's received a disclaimer of audit opinion on its FY 2001 financial statements. Consistent with Statement of Federal Financial Accounting Standards (SFFAS) No. 21, Reporting Corrections of Errors and Changes in Accounting Principles, NASA has restated its FY 2001 financial statements to correct material errors. While this did not remove the disclaimer of audit opinion associated with FY 2001 statements, it provided FY 2002 beginning balances so that NASA's independent public accountant was able to express an unqualified audit opinion on the FY 2002 financial statements.

The following is a brief description of each required financial statement and its relevance and a discussion of significant account balances and financial trends.

The Consolidated Balance Sheet uses a format allowing comparison of financial information for FY 2002 and FY 2001. It presents NASA's assets, amounts owed (liabilities), and equity (net position). The Consolidated Balance Sheet reflects total assets of $44.2 billion and liabilities of $4.4 billion for FY 2002. Unfunded liabilities reported in the statements cannot be liquidated without legislation that provides resources to do so.

About 79 percent of the assets are property, plant, and equipment, with a total book value of $35.1 billion. This is property located at NASA installations (primarily the Centers), in space, and in contractor custody. NASA holds almost 69 percent of these assets, while the remaining 31 percent is in contractor custody. The book value of Assets in Space, which are various spacecraft operating above the atmosphere, constitutes $17.0 billion, or 71 percent, of NASA-owned and NASA-held property, plant, and equipment.

Cumulative Results of Operations represents the public's investment in NASA, akin to stockholder's equity in private industry. This investment is valued at $35.9 billion. The Agency's $39.8 billion net position includes $3.9 billion of unexpended appropriations (undelivered orders and unobligated amounts, or funds provided but not yet spent). Net position is shown on both the Consolidated Balance Sheet and the Consolidated Statement of Changes in Net Position.

The Consolidated Statement of Net Cost presents the "income statement" (the annual cost of programs) and distributes fiscal year expenses by program category. A chart depicting the distribution of expenses is included under "Appropriations Used (Costs Expensed by Enterprise)" in this overview. The Net Cost of Operations is reported on the Consolidated Statement of Net Cost, the Consolidated Statement of Changes in Net Position, and the Combined Statement of Financing.

NASA makes substantial research and development investments on behalf of the Nation. To determine the net cost of operations, these amounts are expensed as incurred. Total Program Expenses are reported on the Consolidated Statement of Net Cost and also on the table entitled "Required Supplementary Stewardship Information Statement regarding Stewardship Investments: Research and Development." Research and development includes all direct, incidental, and related costs that either result from or are necessary to perform research and development, whether the research and development is performed by Federal agencies or by individuals and organizations under grant or contract. The "Required Supplementary Stewardship Information Statement regarding Stewardship Investments: Research and Development" identifies research and development investments by program; it relates to program expenses shown on the Consolidated Statement of Net Cost.

These investments fall into three categories: basic research, applied research, and development. The objective of basic research is to increase knowledge of the fundamental aspects of phenomena without regard to applications to specific processes or products. The objective of applied research is to gain knowledge to determine how to meet a recognized, specific need. Development is the systematic use of the knowledge gained from research to produce useful materials, devices, systems, or methods, including design and development of prototypes and

processes. It excludes quality control, routine product testing, and production.

NASA carried out its mission in FY 2002 through five Strategic Enterprises comprising the following major program areas: Space Science, Earth Science, Biological and Physical Research, Human Exploration and Development of Space, and Aerospace Technology. Funds are allocated by appropriation and then to programs. The Consolidated Statement of Net Costs distributes fiscal year expenses by programmatic category (budget line item).

The Consolidated Statement of Changes in Net Position identifies appropriated funds used to pay for goods, services, or capital acquisitions. This statement presents accounting events that changed the net position section of the Consolidated Balance Sheet between the beginning and the end of the reporting period.

The Combined Statement of Budgetary Resources highlights the Agency's budget authority. It provides information on budgetary resources available to NASA during the year and the status of those resources at the end of the year. Detail on the amounts shown in the Combined Statement of Budgetary Resources is included in the display entitled "Required Supplementary Information: Combined Schedule of Budgetary Resources." Outlays reported in this statement reflect cash disbursements by the U.S. Department of the Treasury for NASA for the fiscal year.

Budget Authority is the authority that Federal law gives to agencies to incur financial obligations that will eventually result in outlays or expenditures. Specific forms of budget authority that NASA receives are appropriations and spending authority from offsetting collections. For FY 2002, Congress provided NASA total appropriations of $14.9 billion. The funding was received and allocated through the following appropriations:

Human Space Flight—This appropriation provided for the International Space Station and Space Shuttle programs, including the development of the Space Station research facilities; continued safe, reliable access to space through investments to improve Space Shuttle safety; support of payload and expendable launch vehicle operations; and other investments including innovative technology development and commercialization.

Science, Aeronautics, and Technology—This appropriation provided for NASA's research and development activities, including all science activities, global change research, aeronautics, technology investments, education programs, space operations, and direct program support.

Inspector General—This appropriation provided for the workforce and other resources to perform audits, levaluations, and investigations of NASA's programs and operations.

The Combined Statement of Financing reconciles the obligations incurred to finance operations with the net costs of operating programs. Costs that do not require resources include depreciation.

Costs capitalized on the Consolidated Balance Sheet are additions to capital assets made during the fiscal year. Obligations Incurred include amounts of orders placed, contracts awarded, services received, and similar transactions that require payment during the same or a future period. Obligations Incurred links the Combined Statement of Budgetary Resources to the Combined Statement of Financing.

REQUIRED SUPPLEMENTARY STEWARDSHIP INFORMATION

Required Supplementary Stewardship Information (RSSI) provides both financial and non-financial information on resources and responsibilities not measured by traditional financial reporting methods. This report presents two categories of Required Supplementary Stewardship Information:

Heritage Assets—These are properties, plant, and equipment that possess historical or natural significance; cultural, educational, or aesthetic value; or significant architectural characteristics. Heritage assets are reported simply as physical units rather than with a dollar valuation, because their existence itself is the most relevant aspect of their value. For FY 2002, NASA reported 1,581 heritage assets.

Stewardship Investments (Research and Development)—These are NASA-funded investments that yield long-term benefits to the general public. They include basic research, applied research, and development. In FY 2002, these investments totaled approximately $8.5 billion. They included activities to expand knowledge of the Earth, the space environment, and the universe and to invest in aeronautics and space transportation technologies that support U.S. economic, scientific, and technical competitiveness. These investments are identified by program on the "Required Supplementary Stewardship Information Statement regarding Stewardship Investments: Research and Development" table, and tie to the related program expenses shown on the Consolidated Statement of Net Cost.

REQUIRED SUPPLEMENTARY INFORMATION

Required Supplementary Information (RSI) presents a complete picture of financial results, position, and condition. This information comprises intragovernmental activities, deferred maintenance, and budgetary resources. Intragovernmental Activities are transactions that occur between Federal agencies. Deferred Main-

tenance (DM) is maintenance that was not performed when it was needed, including maintenance that had been scheduled to be performed but was delayed until a future period.

CHANGE IN APPROPRIATION STRUCTURE FOR FY 2002

In the FY 2001 appropriation structure, the Mission Support appropriation provided a portion of the direct support required to execute NASA's programs. This included research and operations support, civil service salaries, and travel. The new FY 2002 appropriation structure reflects NASA's move to full cost management. In this new structure, the budget for the support items previously included in the Mission Support appropriation is now all included directly in program and project budgets. The budget for FY 2002 includes three appropriations: Human Space Flight; Science, Aeronautics and Technology; and the Inspector General.

Programmatically, the budget for FY 2002 supported both near-term priorities, such as flying the Shuttle safely and building and operating the International Space Station, and longer-term investments in America's future, such as developing more affordable, reliable means of access to space and conducting cutting-edge scientific and technological research. It continued to support our traditional strengths in engineering and science as well as revolutionary insights and capabilities on the horizon in areas such as biotechnology, nanotechnology, and information technology.

Financial Statements

INTRODUCTION TO FINANCIAL STATEMENTS

The Chief Financial Officer's Act of 1990 requires that agencies prepare financial statements to be audited in accordance with Government Auditing Standards. These financial statements reflect the overall financial position of offices and activities, including assets and liabilities, and the results of operations, pursuant to the requirements of 31 U.S. Code 3515b. The statements have been prepared from NASA's books and records in accordance with OMB Bulletin Number 01-09.

These statements are in addition to separate financial reports prescribed by the OMB and the Department of the Treasury (Treasury) which are used to monitor and control budgetary resources, prepared from the same books and records. The statements should be read with the understanding they are for a component of the U.S. Government, a sovereign entity. For example, Treasury, another Federal Agency, holds NASA's Fund Balance. Also, NASA has no authority to pay liabilities not covered by budgetary resources. Liquidation of such liabilities requires enactment of an appropriation by Congress.

National Aeronautics and Space Administration
Consolidated Balance Sheet
September 30, 2002 and 2001
(In Thousands of Dollars)

	2002	2001 (Restated)
Assets:		
Intragovernmental Assets:		
Fund Balance with Treasury (Note 2)	$ 6,766,494	$ 6,320,749
Investments (Note 3)	17,083	16,871
Accounts Receivable, Net (Note 4)	53,544	71,977
Advances and Prepaid Expenses	21,274	22,035
Total Intragovernmental Assets:	6,858,395	6,431,632
Accounts Receivable, Net (Note 4)	8,972	9,137
Materials and Supplies (Note 5)	2,208,064	1,678,791
Property, Plant and Equipment, Net (Note 6)	34,973,293	35,865,043
Advances and Prepaid Expenses	44,907	41,169
Total Assets	**$ 44,093,631**	**$ 44,025,772**
Liabilities:		
Intragovernmental Liabilities:		
Accounts Payable	$ 181,244	$ 160,418
Other Liabilities (Notes 7 and 8)	232,713	89,662
Total Intragovernmental Liabilities	413,957	250,080
Accounts Payable	2,326,774	2,719,115
Environmental Cleanup (Notes 1 and 8)	1,271,937	1,345,869
Other Liabilities (Notes 7 and 8)	418,480	499,424
Total Liabilities	**4,431,148**	**4,814,488**
Net Position:		
Unexpended Appropriations	3,903,145	3,325,591
Cumulative Results of Operations	35,759,338	35,885,693
Total Net Position	**39,662,483**	**39,211,284**
Total Liabilities and Net Position	**$ 44,093,631**	**$ 44,025,772**

The accompanying notes are an integral part of this statement.

National Aeronautics and Space Administration
Consolidated Statement of Net Cost
For the Fiscal Year ended September 30, 2002 and 2001
(In Thousands of Dollars)

	2002	2001 (Restated)
Program Costs by Enterprise:		
Human Exploration and Development of Space		
Intragovernmental Costs	$ 410,872	$ 340,206
Less: Intragovernmental Earned Revenue	209,994	204,363
Intragovernmental Net Costs	200,878	135,843
Gross costs with the Public	6,105,276	1,541,511
Less: Earned Revenue from the Public	24,731	44,086
Net Costs with the Public	6,080,545	1,497,425
Total Net Cost	6,281,423	1,633,268
Space Science		
Intragovernmental Costs	156,399	179,570
Less: Intragovernmental Earned Revenue	41,287	44,938
Intragovernmental Net Costs	115,112	134,632
Gross costs with the Public	2,711,782	1,629,583
Less: Earned Revenue from the Public	2,334	2,328
Net Costs with the Public	2,709,448	1,627,255
Total Net Cost	2,824,560	1,761,887
Earth Science		
Intragovernmental Costs	498,131	143,773
Less: Intragovernmental Earned Revenue	361,219	344,410
Intragovernmental Net Costs	136,912	(200,637)
Gross costs with the Public	1,363,449	947,536
Less: Earned Revenue from the Public	12,174	1,483
Net Costs with the Public	1,351,275	946,053
Total Net Cost	1,488,187	745,416
Biological and Physical Research		
Intragovernmental Costs	33,375	26,685
Less: Intragovernmental Earned Revenue	425	370
Intragovernmental Net Costs	32,950	26,315
Gross costs with the Public	687,777	187,847
Less: Earned Revenue from the Public	544	–
Net Costs with the Public	687,233	187,847
Total Net Cost	720,183	214,162
Aerospace Technology		
Intragovernmental Costs	223,290	214,530
Less: Intragovernmental Earned Revenue	57,724	54,878
Intragovernmental Net Costs	165,566	159,652
Gross costs with the Public	2,621,948	1,117,877
Less: Earned Revenue from the Public	18,280	26,226
Net Costs with the Public	2,603,668	1,091,651
Total Net Cost	2,769,234	1,251,303
Other Programs		
Academic Programs	115,580	139,129
Less: Earned Revenue from the Public	465	–
Total Academic Program Costs	115,115	139,129
Other Programs	140,672	131,728
Less : Intragovernmental Earned Revenue	1,703	(9)
Total Other Program Costs	138,969	131,737
Total Net Cost	254,084	270,866
Net cost of operations (Notes 11 and 14)	$ 14,337,671	$ 5,876,902

The accompanying notes are an integral part of this statement.

National Aeronautics and Space Administration
Consolidated Statement of Changes in Net Position
For the Fiscal Year Ended September 30, 2002
(In Thousands of Dollars)

	2002 Cumulative Results of Operations	2002 Unexpended Appropriations
Beginning Balances (Note 1)	$ 35,885,693	$ 3,325,591
Budgetary Financing Sources:		
Appropriations Received		14,902,826
Appropriations Used	14,282,068	(14,282,068)
Unexpended Appropriations—Adjustments	–	(43,204)
Nonexchange Revenue	1,212	–
Donations	3	–
Other Financing Sources:		
Transfers In/(Out) Without Reimbursement	(284,401)	–
Imputed Financing	212,434	–
Total Financing Sources	14,211,316	577,554
Net Cost of Operations	(14,337,671)	–
Ending Balances	$ 35,759,338	3,903,145

The accompanying notes are an integral part of this statement.

National Aeronautics and Space Administration
Combined Statement of Budgetary Resources
For the Fiscal Year Ending September 30, 2002
(In Thousands of Dollars)

		2002
Budgetary Resources:		
Budgetary authority:		
Appropriation Realized	$	14,902,826
Net Transfers, Current Year Authority		–
Unobligated balance:		
Unobligated Balance, Brought Forward, October 1		873,941
Spending from Offsetting Collections:		
Earned		
Collected		759,500
Receivable from Federal Sources		(17,160)
Change in Unfilled Orders		
Advance Received		131,502
Without Advance from Federal Sources		(58,610)
Recoveries of prior year obligations, actual		102,353
Permanently not available		
Cancellations of Expired/No-Year Accounts		(36,935)
Authority Unavailable Pursuant to Public Law		(10,013)
Total Budgetary Resources		**16,647,404**
Status of Budgetary Resources:		
Obligations Incurred (Note 13)		
Direct		14,789,386
Reimbursable		730,098
Total Obligations Incurred		**15,519,484**
Unobligated Balance		
Apportioned		936,119
Unobligated Balance, Not Available		191,801
Total Unobligated Balances		**1,127,920**
Status Budgetary Resources		**16,647,404**
Obligated Balance, Net as of October 1		5,460,861
Obligated Balance, End of Period		
Accounts Receivable		(58,094)
Unfilled Customer Orders		(54,623)
Undelivered Orders		3,113,677
Accounts Payable		2,632,836
Outlays		
Disbursements		15,320,357
Collections		(891,002)
Subtotal		**14,429,355**
Less: Offsetting Receipts		3
Net Outlays	**$**	**14,429,352**

The accompanying notes are an integral part of this statement.

National Aeronautics and Space Administration
Consolidated Statement of Financing
For the Fiscal Year Ended September 30, 2002
(In Thousands of Dollars)

		2002
Resources Used to Finance Activities:		
Budgetary Resources Obligated		
Obligations Incurred	$	15,519,484
Less: Spending authority from offsetting collections and recoveries		(917,585)
Obligations net of offsetting collections and recoveries		14,601,899
Offsetting receipts		(3)
Net obligations		14,601,896
Other Resources:		
Imputed financing from costs absorbed by others		212,434
Net Other Resources Used to Finance Activities		212,434
Total Resources Used to Finance Activities		14,814,330
Resources Used to Finance Items not Part of the Net Cost of Operations		
Change in Budgetary Resources Obligated for Goods, Services and Benefits Ordered But Not Yet Provided		(384,825)
Resources That Fund Expenses Recognized in Prior Periods		(165,806)
Budgetary Offsetting Collections and Receipts that Do Not Affect the Net Costs of Operations - Other		1,212
Resources that Finance the Acquisition of Assets		(3,621,434)
Total Resources Used to Finance Items Not Part of the Net Cost of Operations		(4,170,853)
Total Resources Used to Finance the Net Cost of Operations		10,643,477
Components Not Requiring or Generating Resources		
Depreciation		3,694,194
Total Components of Net Cost of Operations that will not Require or Generate Resources		3,694,194
Total Components of Net Cost of Operations that will not Require or Generate Resources in the Current Period		3,694,194
Net Cost of Operations	$	14,337,671

The accompanying notes are an integral part of this statement.

National Aeronautics and Space Administration
Notes to Financial Statements
For the Fiscal Year Ended September 30, 2002

1. SUMMARY OF ACCOUNTING POLICIES AND OPERATIONS

Reporting Entity

NASA is an independent Agency established to plan and manage the future of the Nation's civil aeronautics and space program. It has five Strategic Enterprises—Space Science, Earth Science, Biological and Physical Research, Human Exploration and Development of Space, and Aerospace Technology—to implement its mission and communicate with external customers. These financial statements reflect all activities including those of its nine Centers, Headquarters, and the Jet Propulsion Laboratory, which is a Federally Funded Research and Development Center owned by NASA but managed by an independent contractor. Financial management of operations is the responsibility of officials at all organizational levels. The accounting system consists of ten distinct operations located at the Centers. Although each Center is independent of the other and has its own chief financial officer, they operate under Agency-wide financial management policies. These accounting systems provide basic information necessary to meet internal and external budget and financial reporting requirements and provide fund control and accountability. All significant intra-entity activities have been eliminated.

Basis of Presentation

These financial statements include the Consolidated Balance Sheet and the related Consolidated Statements of Net Cost as of September 30, 2002 and 2001, and the related Consolidated Statement of Changes in Net Position, Combined Statement of Budgetary Resources, and Consolidated Statement of Financing for the FY ended September 30, 2002, as required by the Chief Financial Officer's Act of 1990 and the Government Management Reform Act of 1994. They were prepared from the books and records of NASA, in accordance with Generally Accepted Accounting Principles and accounting policies and practices summarized in this note. These financial statements were prepared under the accrual basis of accounting, where expenses and revenues are recorded in the period in which they are incurred or earned, respectively.

Budgets and Budgetary Accounting

NASA is funded by three appropriations, which require individual treatment in the accounting and control system. Reimbursements to appropriations total approximately $731 and $723 million for FYs 2002 and 2001, respectively. As part of its reimbursable program, NASA launches devices into space and provides tracking and data relay services for the U.S. Department of Defense, the National Oceanic and Atmospheric Administration, and the National Weather Service.

On the Statement of Budgetary Resources, Unobligated Balances—Available represents the amount remaining in accounts that are available for obligation in future fiscal years. Unobligated Balances—Not Available represents the amount remaining in appropriation accounts that can only be used for adjustments to previously recorded obligations.

Use of Estimates

Preparation of financial statements in conformity with generally accepted accounting principles requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities and the disclosure of contingent liabilities as of the date of the financial statements and the reported amounts of revenues and expenses during the reporting period. Actual results could differ from these estimates.

Fund Balance With Treasury

Cash receipts and disbursements are processed by Treasury. Fund Balance with Treasury includes appropriated funds, trust funds, deposit funds, and budget clearing accounts.

Investments in U.S. Government Securities

Intragovernmental non-marketable securities include the following investments:

(1) National Aeronautics and Space Administration Endeavor Teacher Fellowship Trust Fund established from public donations in tribute to the crew of the Space Shuttle Challenger.

(2) Science Space and Technology Education Trust Fund established for programs to improve science and technology education.

Accounts Receivable

Most receivables are for reimbursement of research and development costs related to satellites and launch services. The allowance for uncollectible accounts is based upon evaluation of accounts receivable, considering the probability of failure to collect based upon current status, financial and other relevant characteristics of debtors, and

the relationship with the debtor. Under a cross-servicing arrangement, most accounts receivable over 180 days delinquent are turned over to Treasury for collection (the receivable remains on NASA's books until Treasury determines the receivable is uncollectible).

Advances to Others

NASA provides funds to recipients under the University Contracts and Grants Program by drawdowns on letters of credit or through predetermined payment schedules. Recipients are required to schedule drawdowns to coincide with actual, immediate cash needs, in accordance with Treasury regulations. Quarterly reporting by recipients is provided on Federal Cash Transaction Reports (SF 272). The California Institute of Technology, which manages the Jet Propulsion Laboratory, is a major recipient of funds under letter of credit procedures. Detailed monitoring and accountability records are maintained. Monitoring includes audits by the Defense Contract Audit Agency (DCAA) and NASA's Office of Inspector General.

Prepaid Expenses

Payments in advance of receipt of goods or services are recorded as prepaid expenses at the time of payment and recognized as expenses when related goods or services are received.

Materials and Supplies

Materials held by Centers and contractors that are repetitively procured, stored, and issued on the basis of demand are considered Materials and Supplies. Certain NASA contractors' inventory management systems do not distinguish between items that should be classified as materials and those that should be classified as depreciable property. NASA has estimated the relative amounts of materials and property accounted for in these systems using sampling techniques and statistical simulation models.

Property, Plant, and Equipment

NASA-owned property, plant, and equipment are held by the Agency and its contractors and grantees. Property with a unit cost of $100,000 or more and a useful life of 2 years or more is capitalized; all other property is expensed when purchased. Capitalized costs include all costs incurred by NASA to bring the property to a form and location suitable for its intended use. NASA and its contractors and grantees maintain physical accountability for all property, plant, and equipment regardless of cost.

During FY 2001, the accounting methods used to account for Space Shuttles were changed. Prior to FY 2001, the Orbiter and its various component pieces were capitalized and depreciated as separate items with differing useful lives. Beginning in FY 2001, each Orbiter and its various component pieces are capitalized and depreciated as one item with a single useful life.

Corrections to externally provided documentation were recorded during FY 2001 for property transferred to NASA from another Federal agency. The property was fully depreciated; therefore there was no effect on the Balance Sheet asset value. Land transferred from the Department of the Navy to Ames Research Center at Moffett Field, was adjusted to reflect the historical cost rather than fair market value.

Under provisions of the Federal Acquisition Regulation (FAR), contractors are responsible for control over and accountability for Government-owned property in their possession. NASA's contractors and grantees report on NASA property in their custody annually.

Capitalized costs for internally developed software include the full costs (direct and indirect) incurred during the software development phase only. For purchased software, capitalized costs include amounts paid to vendors for the software and material internal costs incurred by the Agency to implement and make the software ready for use through acceptance testing. When NASA purchases software as part of a package of products and services (for example., training, maintenance, data conversion, reengineering, site licenses, and rights to future upgrades and enhancements), capitalizable and noncapitalizable costs of the package are allocated among individual elements on the basis of a reasonable estimate of their relative fair values. Costs that are not susceptible to allocation between maintenance and relatively minor enhancements are expensed.

These financial statements report depreciation expense using the straight-line method. Useful lives are 40 years for buildings; 15 years for other structures and facilities; 15 years for leasehold improvements, 15 years for space hardware; 7 years for special test equipment and tooling; and 5 to 20 years for other equipment depending on its nature. In FY 2002, NASA management decided to maintain the Space Shuttle fleet capability through 2020, thereby extending the useful lives of these assets from 25 years to between 28 and 39 years. The effect of this change in estimate decreased depreciation expense for the year ended September 30, 2002, by approximately $92.8 million. Useful lives for assets in space are their mission lives, ranging from 2 to 20 years.

International Space Station

In previous fiscal years, the asset value of the International Space Station was based on budget estimates and did not include the total costs to bring the Station to a form and location suitable for its intended use. In FY 2001, NASA worked with its contractors to more accurately reflect the full cost of the Station. The

FY 2001 balances have been restated to reflect the actual costs of the Station, including transportation costs (that is, Space Shuttle launch costs) and associated depreciation. NASA began depreciating the Station in FY 2001 when manned by the first permanent crew. Only the Station's major elements in space are depreciated; any on-ground elements are reported as work in process until launched and incorporated into the existing Station structure. The Station is based on a lifetime of 10 years, counting from the time it is fully assembled.

Barter Transactions

NASA utilizes non-monetary transactions in the form of barter agreements with International Partners that govern the reciprocal exchange of goods and services. The Station international agreements are committed to minimize the exchange of funds among partners, by utilizing non-monetary transactions in the form of barter agreements with International Partners. NASA's policy is to record barter transactions based upon the fair value of the non-monetary assets transferred to or from an enterprise, whichever is more readily determinable. Fair value is determined by referring to estimated realizable values in cash transactions of the same or similar assets, quoted market prices, independent appraisals, estimated fair values of assets or services received in exchange, and other available evidence. If fair value of either is not readily determinable within reasonable limits, no value is ascribed to the non-monetary transactions in accordance with Accounting Principles Bulletin No. 29, Accounting for Nonmonetary Transactions. When fair value is readily determinable, barter transactions are recorded as an asset to Government-Held/Government-Owned Equipment with a corresponding liability to Liability for Assets Obtained Under Barter Agreements.

Advances from Others

Advances from Others represent amounts advanced by other Federal and non-Federal entities for goods or services to be provided and are included in other liabilities in the financial statements.

Liabilities Covered by Budgetary Resources

Accounts payable includes amounts recorded for receipt of goods or services furnished. Additionally, NASA accrues costs and recognizes liabilities based on information provided monthly by contractors on Contractor Financial Management Reports (Forms 533M and 533Q). The DCAA performs independent audits to ensure reliability of reported costs and estimates. To provide further assurance, financial managers are required to test the accuracy of form 533 generated cost accruals each month, and NASA Headquarters independently analyzes the validity of Centers' data.

Liabilities and Contingencies Not Covered by Budgetary Resources

Liabilities not covered by budgetary resources include certain environmental matters, legal claims, pensions and other retirement benefits (ORB), workers' compensation, annual leave (see discussion below), and closed appropriations.

Liabilities not covered by budgetary resources consist primarily of environmental cleanup costs as required by Federal, State, and local statutes and regulations. Where up-to-date site-specific engineering estimates for cleanup are not available, parametric models are used to estimate the total cost of cleaning up known contamination at these sites over future years. NASA estimates the total cost of environmental cleanup to be $1.3 billion for the years ending September 30, 2002 and 2001, respectively, and recorded an unfunded liability in its financial statements for these amounts. This estimate could change in the future due to identification of additional contamination, inflation, deflation, and changes in technology or applicable laws and regulations. NASA believes that the estimated environmental liability could range from $807 million to $1.7 billion because of potential future changes to the engineering assumptions underlying the estimates. The estimate represents an amount that will be spent to remediate currently known contamination, subject to the availability of appropriated funds. Other responsible parties that may be required to contribute to the remediation funding could share this liability. NASA was appropriated $44 million and $37 million for the fiscal years ended September 30, 2002 and 2001 respectively, for environmental compliance and restoration. Included in the recorded liability is $28 million and $20 million for the fiscal years ended September 30, 2002 and 2001, respectively, for cleanup of current operations.

NASA is a party in various administrative proceedings, court actions (including tort suits), and claims brought by or against it. In the opinion of management and legal counsel, the ultimate resolution of these proceedings, actions, and claims will not materially affect the financial position, net cost, changes in net position, budgetary resources, or financing of NASA. Liabilities have been recorded for $2 million and $104 million for these matters as of September 30, 2002 and 2001, respectively.

Contingencies, related to proceedings, actions, and claims where management believes, after consultation with legal counsel, are possible but not probable that some costs will be incurred, ranging from zero to $49 million and from zero to $30 million, as of September 30, 2002 and 2001, respectively. No balances have been recorded in the financial statements for these contingencies.

A liability for $82 million was recorded as of September 30, 2002, for workers' compensation claims related to the Federal Employees' Compensation Act (FECA), administered by the U.S. Department of Labor. The FECA provides income and medical cost protection to covered Federal civilian employees injured on the job, employees who have incurred a work-related occupational disease, and beneficiaries of employees whose death is attributable to a job-related injury or occupational disease. The FECA Program initially pays valid claims and subsequently seeks reimbursement from the Federal agencies employing the claimants. The FECA liability includes the actuarial liability of $67 million for estimated future costs of death benefits, workers' compensation, and medical and miscellaneous costs for approved compensation cases. The present value of these estimates at the end of FY 2002 was calculated by the Department of Labor using a discount rate of 5.21 percent for FY 2001 and thereafter. This liability does not include the estimated future costs for claims incurred but not reported or approved as of September 30, 2002.

NASA has recorded approximately $48 million in accounts payable related to closed appropriations for which there is a contractual commitment to pay. These payables will be funded from appropriations available for obligation at the time a bill is processed, in accordance with Public Law 101-510.

Annual, Sick, and Other Leave

Annual leave is accrued as it is earned; the accrual is reduced as leave is taken. Each year, the balance in the accrued annual leave account is adjusted to reflect current pay rates. To the extent current or prior year appropriations are not available to fund annual leave earned but not taken, funding will be obtained from future financing sources. Sick leave and other types of non-vested leave are expensed as taken.

Employee Benefits

Agency employees participate in the Civil Service Retirement System (CSRS), a defined benefit plan, or the Federal Employees Retirement System (FERS), a defined benefit and contribution plan. For CSRS employees, NASA makes contributions of 8.51 percent of pay. For FERS employees, NASA makes contributions of 10.7 percent to the defined benefit plan, contributes 1 percent of pay to a retirement savings plan (contribution plan), and matches employee contributions up to an additional 4 percent of pay. For FERS employees, NASA also contributes the employer's matching share for Social Security.

Statements of Federal Financial Accounting Standards No. 5, "Accounting for Liabilities of the Federal Government," requires Government agencies to report the full cost of employee benefits for CSRS, FERS, the Federal Employee Health Benefits (FEHB), and the Federal Employees Group Life Insurance (FEGLI) Programs. NASA used the applicable cost factors and imputed financing sources from the Office of Personnel and Management Letter F-02-312 in these financial statements.

Reclassifications and Restatement of Prior Period Financial Statements

Certain reclassifications have been made to prior year amounts to conform to the current year presentation resulting from the NASA adoption of OMB Bulletin 01-09, "Form and Content."

Further, NASA has restated its FY 2001 financial statements to correct material errors. FASAB No. 21, Reporting of Errors and Changes in Accounting Principles ("FASAB No. 21"), requires that errors discovered in previously issued financial statements be corrected by restating the affected period. If the error occurred prior to the earliest period presented, the cumulative effect should be reported as a prior period adjustment. NASA detected certain errors during 2002 that occurred in prior years and recorded those errors as if they had occurred in FY 2001. NASA was not able to determine what portion of those errors related to each respective prior year and should have been recorded as prior period adjustments to Property, Plant and Equipment, Materials and Cumulative Results of Operations as of the beginning of FY 2001. Instead, NASA has restated its FY 2001 financial statements and has recorded in its balance sheet and statement of net cost ($2.8 billion) in adjustments relating to corrections of errors caused primarily by the lack of internal controls surrounding Contractor-Held Property, Plant and Equipment and Materials and NASA-Owned Assets-in-Space and WIP.

2. Fund Balance With Treasury:
(In Thousands of Dollars)

September 30, 2002

Fund Balances:	Obligated	Unobligated—Available	Unobligated—Not Available	Total
Appropriated Funds	$ 5,633,289	$ 936,119	$ 174,474	$ 6,743,882
Trust Funds	118	–	3,508	3,626
Total	$ 5,633,407	$ 936,119	$ 177,982	6,747,508
Clearing and Deposit Accounts				18,986
Total Fund Balance With Treasury				$ 6,766,494

September 30, 2001

Fund Balances:	Obligated	Unobligated Available	Unobligated Not Available	Total
Appropriated Funds	$ 5,460,673	$ 797,657	$ 58,918	$ 6,317,248
Trust Funds	190	–	3,670	3,860
Total	$ 5,460,863	$ 797,657	$ 62,588	6,321,108
Clearing and Deposit Accounts				(359)
Total Fund Balance With Treasury				$ 6,320,749

Obligated balances represent the cumulative amount of obligations incurred, including accounts payable and advances from reimbursable customers, for which outlays have not yet been made. Unobligated available balances represent the amount remaining in appropriation accounts that are available for obligation in the next fiscal year. Unobligated balances not available represent the amount remaining in appropriation accounts that can be used for adjustments to previously recorded obligations. Unobligated balances not available are the result of settling obligated balances for less than what was obligated. Unobligated trust fund balances not available represent amounts that must be apportioned by the OMB before being used to incur obligations.

Clearing accounts are used for unidentified remittances presumed to be applicable to budget accounts but are being held in the clearing account because the specific appropriation account is not yet known. Deposit account balances represent amounts withheld from employees' pay for U.S. Savings Bonds and State tax withholdings which will be transferred in the next fiscal year.

3. Investments:
(In Thousands of Dollars)

September 30, 2002

	Par Value	Amortization Method	Discounts and Premiums, Net	Interest Receivable	Net Amount Invested
Intragovernmental Non-Marketable Securities	$ 13,825	Interest method	$ 3,113	$ 145	$ 17,083

September 30, 2001

	Par Value	Amortization Method	Discounts and Premiums, Net	Interest Receivable	Net Amount Invested
Intragovernmental Non-Marketable Securities	$ 13,706	Interest method	$ 3,022	$ 143	$ 16,871

Intragovernmental securities are non-marketable Treasury securities issued by the Bureau of Public Debt.

Interest rates range from 1.56 percent to 6.60 percent and from 2.27 percent to 7.59 percent for the fiscal years ended September 30, 2002 and 2001, respectively.

The interest method was used to amortize discounts and premiums.

4. Accounts Receivable, Net:
(In Thousands of Dollars)

September 30, 2002

	Accounts Receivable	Allowance for Uncollectible Accounts	Net Amount Due
Intragovernmental	$ 53,544	$ –	$ 53,544
Governmental	10,023	(1,051)	8,972
Total	$ 63,567	$ (1,051)	$ 62,516

September 30, 2001

	Accounts Receivable	Allowance for Uncollectible Accounts	Net Amount Due
Intragovernmental	$ 71,978	$ (1)	$ 71,977
Governmental	10,008	(871)	9,137
Total	$ 81,986	$ (872)	$ 81,114

5. Operating Materials and Supplies:
(In Thousands of Dollars)

	September 30	
	2002	**2001** (Restated)
Operating Materials and Supplies, Held for Use	$ 2,204,773	$ 1,674,387
Operating Materials and Supplies, Held in Reserve for Future Use	3,291	4,404
Total	$ 2,208,064	$ 1,678,791

Operating Materials and Supplies, Held for Use, are tangible personal property held by NASA and its contractors to be used for fabricating and maintaining NASA assets. They will be consumed in normal operations. Operating Materials and Supplies, Held in Reserve for Future Use, are tangible personal property held by NASA for emergencies for which there is no normal recurring demand but that must be immediately available to preclude delay, which might result in loss, damage or destruction of Government property, danger to life or welfare of personnel, or substantial financial loss to the Government due to an interruption of operations. All materials are valued using historical costs, or other valuation methods which approximate historical cost. NASA Centers and contractors are responsible for continually reviewing materials and supplies to identify items no longer needed for operational purposes or that need to be replaced. Excess, obsolete, and unserviceable items have been removed from these amounts. There are no restrictions on these items.

For the years ended September 30, 2002 and 2001, $527,521 and $427,454, respectively, was written-off as excess, obsolete and unserviceable inventory.

6. Property, Plant, and Equipment, Net:
(In Thousands of Dollars)

	September 30, 2002		
	Cost	Accumulated Depreciation	Net Asset Value
Government-owned/Government-held:			
Land	$ 115,132	$ –	$ 115,132
Structures, Facilities, and Leasehold Improvements	5,501,471	(3,681,992)	1,819,479
Assets in Space	34,360,780	(17,347,280)	17,013,500
Equipment	1,843,468	(1,250,328)	593,140
Capitalized Leases (Note 10)	3,088	(666)	2,422
Internal Use Software and Development	16,549	(1,819)	14,730
Work-in-Process (WIP)	4,561,011	–	4,561,011
Total	$ 46,401,499	$ (22,282,085)	$ 24,119,414
Government-owned/Contractor-held:			
Land	$ 8,076	$ –	$ 8,076
Structures, Facilities, and Leasehold Improvements	723,453	(468,288)	255,165
Equipment	11,356,434	(8,096,532)	3,259,902
Work-in-Process	7,330,736	–	7,330,736
Total	$ 19,418,699	$ (8,564,820)	$ 10,853,879
Total Property, Plant, and Equipment	$ 65,820,198	$ (30,846,905)	$ 34,973,293

6. Property, Plant, and Equipment, Net (continued)**:**
(In Thousands of Dollars)

	September 30, 2001 (Restated)		
	Cost	**Accumulated Depreciation**	**Net Asset Value**
Government-owned/Government-held:			
Land	$ 114,870	–	$ 114,870
Structures, Facilities, and Leasehold Improvements	5,428,770	(3,486,750)	1,942,020
Assets in Space	30,762,255	(14,965,051)	15,797,204
Equipment	1,857,987	(1,189,727)	668,260
Capitalized Leases (Note 10)	3,471	(401)	3,070
Internal Use Software and Development	7,771	(426)	7,345
Work-in-Process	5,615,123	–	5,615,123
Total	$ 43,790,247	(19,642,355)	$ 24,147,892
Government-owned/Contractor-held:			
Land	$ 8,076	–	$ 8,076
Structures, Facilities, and Leasehold Improvements	714,102	(451,830)	262,272
Equipment	11,485,048	(7,884,074)	3,600,974
Work-in-Process	7,845,829	–	7,845,829
Total	$ 20,053,055	(8,335,904)	$ 11,717,151
Total Property, Plant, and Equipment	$ 63,843,302	(27,978,259)	$ 35,865,043

Assets in space are various spacecraft that operate above the atmosphere for exploration purposes. Equipment includes special tooling, special test equipment, and Agency-peculiar property, such as the Space Shuttle and other configurations of spacecraft: engines, unlaunched satellites, rockets, and other scientific components unique to NASA space programs. Structures, Facilities, and Leasehold Improvements includes buildings with collateral equipment, and capital improvements, such as airfields, power distribution systems, flood control, utility systems, roads, and bridges. NASA also has use of certain properties at no cost. These properties include land at the Kennedy Space Center withdrawn from the public domain and land and facilities at the Marshall Space Flight Center under a no cost, 99-year lease with the U.S. Department of the Army. Work-in-Process (WIP) is the cost incurred for property, plant, and equipment items not yet completed. WIP includes equipment and facilities that are being constructed as well as the fabrication of assets that may or may not be capitalized once completed and operational. If it is determined to not meet capitalization criteria (that is, less than 2-year useful life and less than $100,000), the project will be expensed to the Statement of Net Cost in the year of completion to match outputs to inputs.

NASA has International Space Station (ISS) bartering agreements with the European Space Agency, the Italian Space Agency, the National Space Agency of Japan, the Canadian Space Agency, and the Brazilian Space Agency. NASA barters with these other space agencies to obtain ISS hardware elements in exchange for providing goods and services such as Space Shuttle transportation and a share of NASA's ISS utilization rights. The intergovernmental agreements state that the parties will seek to minimize the exchange of funds in the cooperative program, including the use of barters to provide goods and services. As of September 30, 2002, NASA has received various assets from these parties in exchange for future services. However, due to the fact that fair value is indeterminable, no value was ascribed to these transactions in accordance with APB No. 29. Under all agreements to date, NASA's ISS Program's International Partners Office expects that NASA will eventually receive future NASA-required elements as well with no exchange of funds.

NASA reports the physical existence (in terms of physical units) of heritage assets as part of the required supplemental stewardship information.

7. Other Liabilities:
(In Thousands of Dollars)

	September 30, 2002		
	Current	Non-Current	Total
Intragovernmental Liabilities:			
Advances From Others	186,419	–	186,419
Workers' Compensation	7,245	8,470	15,715
Accrued Funded Payroll	13,885	–	13,885
Accounts Payable for Closed Appropriations	–	2,872	2,872
Liability for Deposit and Clearing Funds	12,652	–	12,652
Custodial Liability	900	–	900
Lease Liabilities	112	158	270
Total Intragovernmental	221,213	11,500	232,713
Liabilities From the Public:			
Unfunded Annual Leave	–	145,638	145,638
Accrued Funded Payroll	109,151	–	109,151
Actuarial FECA Liability	–	67,280	67,280
Accounts Payable for Closed Appropriations	2,251	43,141	45,392
Advances From Others	38,283	–	38,283
Contract Holdbacks	1,782	–	1,782
Custodial Liability	2,785	–	2,785
Contingent Liabilities	–	1,504	1,504
Lease Liabilities	233	96	329
Liability for Deposit and Clearing Funds	6,336	–	6,336
Total From the Public	160,821	257,659	418,480
Total Other Liabilities	382,034	269,159	651,193

	September 30, 2001		
	Current	Non-Current	Total
Intragovernmental Liabilities:			
Advances From Others	55,578	–	55,578
Workers' Compensation	6,406	9,154	15,560
Accrued Funded Payroll	11,964	–	11,964
Accounts Payable for Closed Appropriations	–	2,989	2,989
Liability for Deposit and Clearing Funds	2,086	–	2,086
Custodial Liability	921	–	921
Other Liabilities	151	–	151
Lease Liabilities	106	307	413
Total Intragovernmental	77,212	12,450	89,662
Liabilities From the Public:			
Unfunded Annual Leave	–	139,397	139,397
Accrued Funded Payroll	101,835	–	101,835
Actuarial FECA Liability		69,672	69,672
Accounts Payable for Closed Appropriations	1,851	39,845	41,696
Advances From Others	37,610	–	37,610
Contract Holdbacks	3,120	–	3,120
Custodial Liability	3,144	–	3,144
Other Liabilities	3	–	3
Contingent Liabilities	–	104,397	104,397
Lease Liabilities	418	258	676
Liability for Deposit and Clearing Funds	(2,126)	–	(2,126)
Total From the Public	145,855	353,569	499,424
Total Other Liabilities	223,067	366,019	589,086

Langley Research Center amortized 3 months of the lease liability ($37) and included this amount in Current Accounts Payable. Accordingly, the total amount reported as Net Capital Lease Liability in Note 10, is $37 less than the amount reported in Note 7, Other Liabilities.

8. Liabilities Not Covered by Budgetary Resources:
(In Thousands of Dollars)

	September 30, 2002		
	Current	Non-Current	Total
Intragovernmental Liabilities:			
Workers' Compensation	7,245	8,470	15,715
Accounts Payable for Closed Appropriations	–	2,872	2,872
Total Intragovernmental	7,245	11,342	18,587
From the Public:			
Environmental Cleanup Costs	–	1,271,937	1,271,937
Unfunded Annual Leave	–	145,638	145,638
Actuarial FECA Liability	–	67,280	67,280
Accounts Payable for Closed Appropriations	2,251	43,141	45,392
Contingent Liabilities	–	1,504	1,504
Total From the Public	2,251	1,529,500	1,531,751
Total Liabilities Not Covered by Budgetary Resources	9,496	1,540,842	1,550,338

	September 30, 2001		
	Current	Non-Current	Total
Intragovernmental Liabilities:			
Workers' Compensation	6,406	9,154	15,560
Accounts Payable for Closed Appropriations	–	2,989	2,989
Total Intragovernmental	6,406	12,143	18,549
From the Public:			
Environmental Cleanup Costs	27,726	1,318,143	1,345,869
Unfunded Annual Leave	–	139,397	139,397
Actuarial FECA Liability	–	69,672	69,672
Accounts Payable for Closed Appropriations	1,851	39,845	41,696
Contingent Liabilities	–	104,397	104,397
Total From the Public	29,577	1,671,454	1,701,031
Total Liabilities Not Covered by Budgetary Resources	35,983	1,683,597	1,719,580

See Note 1 for further discussion of liabilities not covered by budgetary resources.

9. Non-Entity Assets:
(In Thousands of Dollars)

	September 30, 2002		
Asset	Intragovernmental	Due from the Public	Total Non-Entity Assets
Accounts Receivable, Net	$ 230	$ 3,455	$ 3,685

	September 30, 2001		
Asset	Intragovernmental	Due from the Public	Total Non-Entity Assets
Accounts Receivable, Net	$ 2,350	$ 1,715	$ 4,065

Accounts receivable related to closed appropriations, which will be deposited in miscellaneous receipts, are included in Non-Entity Assets. These amounts represent NASA's custodial activity and are not separately identified on the Balance Sheet as the amounts are immaterial.

10. Leases:
(In Thousands of Dollars)

Entity as Lessee:	September 30: 2002	2001
Capital Leases:		
Summary of Assets Under Capital Lease:		
Equipment	$ 3,088	$ 3,471
Accumulated Amortization	(2,452)	(2,347)
	$ 636	$ 1,124

Capital leases consist of assorted types of machinery with non-cancelable terms longer than 1 year, a fair market value of $100,000 or more, a useful life of 2 years or more, and agreement terms equivalent to an installment purchase.

Future Minimum Lease Payments:	Fiscal Year	
	2003	$ 420
	2004	267
	2005	–
	2006 and after	–
	Future Lease Payments	687
	Less: Imputed Interest	(51)
	Net Capital Lease Liability	$ 636

Lease liabilities covered by budgetary resources	$ 636
Lease liabilities not covered by budgetary resources	–
Total Lease liabilities	$ 636

Operating Leases—

NASA's FY 2002 operating leases are for an airplane hangar, warehouse storage, copiers, and land.

Future Minimum Lease Payments:

Fiscal Year	Land and Buildings	Equipment	Total
2003	$ 275.0	$ 1,255.0	$ 1,530.0
2004	186.0	107.0	293.0
2005	176.0	2.0	178.0
2006	–	–	–
2007 and after	–	–	–
Total Future Lease Payments	$ 637.0	$ 1,364.0	$ 2,001.0

Entity as Lessor:
Operating Leases—

NASA leases and allows use of its land and facilities by the public and other Government agencies for a fee.

Future Projected Receipts: Fiscal Year	Land and Buildings
2003	$ 437
2004	129
2005	124
2006	70
2007 and after	882
Total Future Operating Lease Receipts	$ 1,642

11. Gross Cost and Earned Revenue By Budget Functional Classification:
(In Thousands of Dollars)

Functional Classification	For the Fiscal Year Ended September 30, 2002		
	Gross Cost	Earned Revenue	Net Cost
General Science, Space, and Technology	$ 14,877,216	$ (654,876)	$ 14,222,340
Transportation	191,119	(76,004)	115,115
Costs Not Assigned to Programs	216	–	216
Total	$ 15,068,551	$ (730,880)	$ 14,337,671

Functional Classification	For the Fiscal Year Ended September 30, 2001		
	Gross Cost	Earned Revenue	Net Cost
General Science, Space, and Technology	$ 5,352,018	$ (671,899)	$ 4,680,119
Transportation	1,107,985	(51,183)	1,056,802
Costs Not Assigned to Programs	139,972	9	139,981
Total	$ 6,599,975	$ (723,073)	$ 5,876,902

12. Statement of Net Cost
(Restated)

The Statement of Net Cost recognizes post-employment benefit expenses of $108 million and $104 million for FY 2002 and 2001, respectively. The expense to Office of Personnel Management represents NASA's share of the current and estimated future outlays for employee pensions, life, and health insurance. Additionally, the Statement includes $104 million and $2 million for FY 2002 and 2001, respectively for the Judgment Fund. The expense attributable to the Treasury's Judgment Fund, represents amounts paid directly from the Judgment Fund.

13. Statement of Budgetary Resources
(In Thousands of Dollars)

Apportionment Categories of Obligations Incurred:

The amounts of direct and reimbursable obligations incurred against amounts apportioned under Categories A and B are displayed below:

	Direct	Reimbursable	Total
2002	$ 14,789,386	$ 730,098	$ 15,519,484

The amounts of obligations incurred against amounts apportioned under Category A are $1,000.

The Budget of the United States Government with actual numbers for FY 2002 has not been published as of January 27, 2003. The document is expected to be published on February 3, 2003. Once published the document may be found at the Office of Management and Budget website, www.whitehouse.gov/omb.

14. Net Cost by Program

(In Thousands of Dollars)

Program/Operating Expenses by Enterprise:	2002	2001 (Restated)
Human Exploration and Development of Space:		
Space Shuttle	$ 3,232,011	$ 2,100,835
Space Station	1,727,749	(1,253,026)
Space Operations	369,737	369,674
Investment and Support	465,881	164,241
Payload Utilization and Operations	180,888	153,324
Safety, Reliability and Quality Assurance	69,868	40,037
Mission Communications Services	253,654	32,199
Space Communications Services	(18,363)	25,776
U.S./Russian Cooperative	(2)	208
Total Human Exploration and Development of Space	6,281,423	1,633,268
Space Science:		
Space Science	2,824,792	1,761,100
Planetary Exploration	(232)	787
Total Space Science	2,824,560	1,761,887
Earth Science:		
Earth Science	1,488,187	745,416
Biological and Physical Research:		
Biological and Physical Research	720,183	214,162
Aerospace Technology:		
Aerospace Technology	2,398,468	1,039,635
Advanced Space Transportation	16,049	83,971
Commercial Technology	354,717	127,697
Total Aerospace Technology	2,769,234	1,251,303
Total Enterprise Program Costs	**14,083,587**	**5,606,036**
Costs Not Assigned to Enterprises:		
Academic Programs	115,115	139,129
Other Programs	138,969	131,737
Total Costs Not Assigned to Enterprises	**254,084**	**270,866**
Net Cost of Operations	**$ 14,337,671**	**$ 5,876,902**

Depreciation expenses in the amount of $3,694,194 and $3,745,261 for FY 2002 and 2001, respectively, have been allocated to the applicable programs based on percentage of current year cost per Center.

Capitalized costs in the amount of $3,621,497 and $12,466,350 for FY 2002 and 2001, respectively, have been allocated to the applicable programs based on percentage of current year cost per Center.

15. Explanation of the Relationship Between Liabilities Not Covered by Budgetary Resources on the Balance Sheet and Resources That Fund Expenses Recognized in Prior Periods

(In Thousands of Dollars)

Liabilities Not Covered by Budgetary Resources of $1,550,338 and $1,719,580 for FY 2002 and 2001, respectively, represent NASA's environmental liability, FECA liability to the Department of Labor and employees, contingent liabilities, accounts payable for closed appropriations and leave earned but not taken (See Note 8, Liabilities Not Covered by Budgetary Resources). The decrease in Liabilities Not Covered by Budgetary Resources is recorded as a decrease to unfunded expenses and reported as Resources That Fund Expenses Recognized in Prior Periods. The difference between the change in Liabilities not Covered by Budgetary Resources and amounts reported as Resources That Fund Expenses Recognized in Prior Periods relates to vendor overpayments.

National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Heritage Assets
For the Fiscal Year Ended September 30, 2002

Federal agencies are required to classify and report heritage assets, in accordance with the requirements of SFFAS No. 8, "Supplementary Stewardship Reporting."

Heritage assets are property, plant, and equipment that possess one or more of the following characteristics: historical or natural significance; cultural, educational, or aesthetic value; or significant architectural characteristics.

Since the cost of heritage assets is usually not relevant or determinable, NASA does not attempt to value them or to establish minimum value thresholds for designation of property, plant, or equipment as heritage assets. The useful lives of heritage assets are not reasonably estimable for depreciation purposes.

Since the most relevant information about heritage assets is their existence, they are reported in terms of physical units, as follows:

	2001	Additions	Withdrawals	2002
Buildings and Structures	37	2	(2)	37
Air and space displays and artifacts	451	69	0	520
Miscellaneous items	1,016	9	(1)	1,024
Total Heritage Assets	1,504	80	(3)	1,581

Heritage assets were generally acquired through construction by NASA or its contractors, and are expected to remain in this category, except where there is legal authority for transfer or sale. Heritage assets are generally in fair condition, suitable only for display.

Many of the buildings and structures are designated as National Historic Landmarks. Numerous air and spacecraft and related components are on display at various locations to enhance public understanding of NASA programs. NASA eliminated their cost from its property records when they were designated as heritage assets. A portion of the amount reported for deferred maintenance is for heritage assets.

In accordance with SFFAS No. 8, as amended, heritage assets whose predominant uses are in general Government operations are considered "multi-use" heritage assets. Such assets are accounted for as general property, plant, and equipment and capitalized and depreciated in the same manner as other general property, plant, and equipment. NASA has 18 buildings and structures considered to be "multi-use" heritage assets. The values of these assets are included in the property, plant, and equipment values shown in the principal financial statements.

For more than 30 years, the NASA Art Program, an important heritage asset, has documented America's major accomplishments in aeronautics and space. During that time, more than 200 artists have generously contributed their time and talent to record their impressions of the U.S. aerospace program in paintings, drawings, and other media. Not only do these art works provide a historic record of NASA projects, they give the public a new and fuller understanding of advancements in aerospace. Artists are, in fact, given a special view of NASA through the "back door." Some have witnessed astronauts in training or scientists at work. The art collection, as a whole, depicts a wide range of subjects, from Space Shuttle launches to aeronautics research, Hubble Space Telescope and even virtual reality.

Artists commissioned by NASA receive a small honorarium in exchange for donating a minimum of one piece to the NASA archive, which now numbers more than 700 works of art. In addition, more than 2,000 works have been donated to the National Air and Space Museum.

National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Stewardship Investments: Research and Development
For the Fiscal Year Ended September 30
(In Thousands of Dollars)

Research and Development Expenses by Enterprise by Programs/Applications

	2002	2001 (Restated)	2000	1999	1998
Human Exploration and Development of Space (HEDS)					
Space Station (a)					
Basic	$ –	$ –	$ –	$ –	$ –
Applied Research	–	–	–	99,678	137,529
Development	–	–	–	2,456,172	2,362,996
Subtotal	$ –	$ –	$ –	$ 2,555,850	$ 2,500,525
Space Operations					
Basic	$ 369,737	$ 147,869	$ 457,582	**$ –**	**$ –**
Applied Research	–	$ 92,419	–	**–**	**–**
Development	–	$ 129,386	–	$ 430,503	$ 444,933
Subtotal	$ 369,737	$ 369,674	$ 457,582	$ 430,503	$ 444,933
Investment and Support (b)					
Basic	$ –	$ –	$ –	$ –	$ –
Applied Research	$ 27,453	$ 164,241	–	–	–
Development	–	–	–	–	–
Subtotal	$ 27,453	$ 164,241	$ –	$ –	$ –
Payload Utilization and Operations					
Basic	$ –	$ –	$ –	$ –	$ –
Applied Research	180,888	153,324	419,452	375,970	401,528
Development	–	–	–	–	–
Subtotal	$ 180,888	$ 153,324	$ 419,452	$ 375,970	$ 401,528
HEDS Total	$ 578,078	$ 687,239	$ 877,034	$ 3,362,323	$ 3,346,986
Space Science (SSE)					
Space Science					
Basic	$ 988,677	$ 581,163	$ 818,718	747,763	$ 672,691
Applied Research	–	–	–	816,433	734,467
Development	1,836,115	1,179,937	1,625,216	979,212	880,904
Subtotal	$ 2,824,792	$ 1,761,100	$ 2,443,934	$ 2,543,408	$ 2,288,062
Planetary Exploration					
Basic	$ –	$ –	$ 11,152	$ 10,049	$ 14,207
Applied Research	–	–	–	10,972	15,511
Development	–	–	$ 22,137	13,160	18,604
Subtotal	$ –	$ –	$ 33,289	$ 34,181	$ 48,322
SSE Total	$ 2,824,792	$ 1,761,100	$ 2,477,223	$ 2,577,589	$ 2,336,384
Earth Science (ESE)					
Basic	$ 544,676	$ 255,678	$ 494,956	$ 358,782	$ 331,095
Applied Research	105,661	55,161	97,018	130,625	156,835
Development	837,850	434,577	1,052,397	1,252,260	1,254,677
Subtotal	$ 1,488,187	$ 745,416	$ 1,644,371	$ 1,741,667	$ 1,742,607
ESE Total	$ 1,488,187	$ 745,416	$ 1,644,371	$ 1,741,667	$ 1,742,607
Biological and Physical Research (BPR) (c)					
Basic	$ 209,573	$ 69,603	$ 107,951	$ 162,858	$ 221,217
Applied Research	415,546	112,221	166,746	119,548	157,727
Development	95,064	32,338	46,586	14,239	20,365
Subtotal	$ 720,183	$ 214,162	$ 321,283	$ 296,645	$ 399,309
BPR Total	$ 720,183	$ 214,162	$ 321,283	$ 296,645	$ 399,309

National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Stewardship Investments: Research and Development
For the Fiscal Year Ended September 30
(In Thousands of Dollars)

Research and Development Expenses by Enterprise by Programs/Applications (continued):

	2002	2001 (Restated)	2000	1999	1998
Aerospace Technology (AT)					
Aerospace Technology					
Basic	$ –	$ –	$ 144,053	$ 356,546	$ 438,923
Applied Research	2,398,468	1,039,635	906,288	910,027	937,011
Development	–	–	$ 83,937	$ 20,595	–
Subtotal	$ 2,398,468	$ 1,039,635	$ 1,134,278	$ 1,287,168	$ 1,375,934
Advanced Space Transportation					
Basic	$ –	$ –	$ –	$ –	$ –
Applied Research	16,049	83,971	512,409	569,775	678,036
Development	–	–	–	–	–
Subtotal	$ 16,049	$ 83,971	$ 512,409	$ 569,775	$ 678,036
Commercial Technology					
Basic	$ –	$ –	$ –	$ 99,080	$ –
Applied Research	342,302	127,697	171,591	45,341	98,198
Development	12,415	–	6,224	23,510	45,788
Subtotal	$ 354,717	$ 127,697	$ 177,815	$ 167,931	$ 143,986
AT Total	$ 2,769,234	$ 1,251,303	$ 1,824,502	$ 2,024,874	$ 2,197,956
Enterprise-wide Academic Programs					
Academic Programs					
Basic	$ 81,271	$ 97,112	$ 71,504	$ 93,339	$ 90,468
Applied Research	33,844	42,017	39,873	19,657	19,481
Development	–	–	–	13,823	37,634
Subtotal	$ 115,115	$ 139,129	$ 111,377	$ 126,819	$ 147,583
Enterprise-wide Academic Programs Total	$ 115,115	$ 139,129	$ 111,377	$ 126,819	$ 147,583
Total Research and Development Expenses by Program	**$ 8,495,589**	**$ 4,798,349**	**$ 7,255,790**	**$ 10,129,917**	**$ 10,170,825**

Non-Research and Development Expenses by Enterprise by Programs/Applications:

Human Exploration and Development of Space (HEDS)					
Space Shuttle	$ 3,232,011	$ 2,100,835	$ 3,303,230	$ 3,285,407	$ 3,369,846
Space Station	1,727,749	$ (1,253,026)	$ 2,754,089	–	–
Investment and Support	438,428	–	–	–	–
Space Communication Services	(18,363)	$ 25,776	–	$ 184,978	$ 254,440
Safety, Reliability and Quality Assurance	69,868	$ 40,037	–	–	–
Mission Communication Services	253,654	$ 32,199	–	–	–
U.S. Russian Cooperative	(2)	208	22,124	151,396	218,109
HEDS Total	$ 5,703,345	$ 946,029	$ 6,079,443	$ 3,621,781	$ 3,842,395
Space Science (SSE)					
Planetary Exploration	(232)	787	–	–	–
SSE Total	(232)	787	–	–	–
Other Programs	138,969	131,737	1,271	832	1,457
Reimbursable Expenses		–	737,498	817,810	715,407
Total Non-Research and Development Expenses by Program	**$ 5,842,082**	**$ 1,078,553**	**$ 6,818,212**	**$ 4,440,423**	**$ 4,559,259**
Total Program Expenses	**$ 14,337,671**	**$ 5,876,902**	**$ 14,074,002**	**$ 14,570,340**	**$ 14,730,084**

National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Stewardship Investments: Research and Development

NASA makes substantial research and development investments for the benefit of the United States. These amounts are expensed as incurred in determining the net cost of operations.

NASA's research and development programs include activities to extend our knowledge of the Earth, its space environment, and the universe, and to invest in new aeronautics and advanced space transportation technologies that support the development and application of technologies critical to the economic, scientific, and technical competitiveness of the United States.

Investment in research and development refers to those expenses incurred to support the search for new or refined knowledge and ideas and for the application or use of such knowledge and ideas for the development of new or improved products and processes with the expectation of maintaining or increasing national economic productive capacity or yielding other future benefits. Research and development is composed of:

Basic research: Systematic study to gain knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind;

Applied research: Systematic study to gain knowledge or understanding necessary for determining the means by which a recognized and specific need may be met; and

Development: Systematic use of the knowledge and understanding gained from research for the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

The strategies and resources that NASA uses to achieve its performance goals are highlighted in the Management's Discussion & Analysis (MD&A) section of this Performance and Accountability Report. The MD&A also provides information regarding the relationship between performance outcomes and outputs to the stewardship investments outlined above. See the MD&A section entitled "Highlights of Performance Goals and Results," for further details.

(a) The OMB revised its rules in FY 2000, and no longer considered International Space Station as Investment in Research and Development, as in previous years. Therefore, in FY 2000, the Space Station became part of Non-Research and Development Expenses by Program.

(b) In FY 2002, NASA's apppropriation structure was realigned to incorporate the functions of the former Mission Support appropriation to Science, Aeronautics and Technology and the Human Space Flight. This realignment change the functionality from a Research and Development program to both Research and Development and non-Research and Development, as indicated on the schedule above.

(c) In FY 2001, NASA established a new enterprise, Biological and Physical Research. This initiative transferred Life and Microgravity to Biological and Physical Research.

Enterprise/Program/Application Descriptions:

Human Exploration and Development of Space Enterprise seeks to expand the frontiers of space and knowledge by exploring, using, and enabling the development of space.

Space Station—The International Space Station is a complex of research laboratories in low-Earth orbit in which American, Russian, Canadian, European, and Japanese astronauts are conducting unique scientific and technological investigations in a micro gravity environment.

The Payload Utilization and Operations Program is the "one-stop shopping provider" for all customer carrier needs and requirements for safe and cost effective access to space via the Space Shuttle.

Investment and Support—Rocket Propulsion Test Support activity will continue to ensure NASA's rocket propulsion test capabilities are properly managed and maintained in world-class condition.

Space Science seeks to chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planetary bodies, and life.

Enterprise/Program/Application Descriptions (continued):

Biological and Physical Research affirms NASA's commitment to the essential role biology will play in the 21st century, and supports the high-priority biological and physical sciences research needed to achieve Agency strategic objectives.

Earth Science develops a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations.

Aerospace Technology works to advance U.S. preeminence in aerospace research and technology. The Enterprise aims to radically improve air travel, making it safer, faster, and quieter as well as more affordable, accessible, and environmentally sound.

Advanced Space Transportation will create a safe, affordable highway through the air and into space by improving safety, reliability, and operability, while significantly reducing the cost of space transportation systems.

Academic Programs consists of two components, the Educational Program and the Minority University Program. Together, these two components of the Academic Programs provide guidance for the Agency's interaction with both the formal and informal education community.

The Space Shuttle is a partially reusable space vehicle that provides several unique capabilities to the U.S. space program. These include retrieving payloads from orbit for reuse; servicing and repairing satellites in space; safely transporting humans to and from space; launching Station components and providing an assembly platform in space; and operation and returning space laboratories.

Space Communications and Data Services supports NASA's Enterprises and external customers with Space Communications and Data System services that are responsive to customer needs.

Space Operation's goal is to provide highly reliable and cost-effective space operations services in support of NASA's science and aeronautics programs.

NASA's Commercial Technology Program facilitates the transfer of NASA inventions, innovations, discoveries, or improvements developed by NASA personnel or in partnership with industry/universities to the private sector.

The U.S./Russian Cooperative Program—This program includes all flight activities in support of the joint space missions involving the Shuttle and the Russian Mir Space Station.

Safety, Reliability and Quality Assurance Program invests in the safety and success of NASA missions by assuring that sound and robust policies, processes, and tools for safety, reliablitty, quality assurance, and engineering disciplines are in place and applied throughout NASA.

The Mission Communication Services Program, one part of NASA's Space Communications Program, provides support to the breadth of NASA missions, including planetary and interplanetary missions; Human Space Flight missions; near-Earth-orbiting and spacecraft missions; suborbital and aeronautical test flight systems.

The Planetary Exploration Program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteroids.

Other Programs includes the mission of the Office of Inspector General and programs not directly supportive of a single Enterprise.

National Aeronautics and Space Administration
Required Supplementary Information
Combined Schedule of Budgetary Resources
For the Fiscal Year Ended September 30, 2002
(In Thousands of Dollars)

	Science, Aeronautics, and Technology	Human Space Flight	Mission Support	Other	Total
Budget Authority:					
Appropriation	$ 7,889,600	$ 6,988,400	$ –	$ 24,826	$ 14,902,826
Net Transfers (+) or (-)	209,968	(209,968)	–	–	–
Unobligated Balance:					
Brought Forward, October 1 (+ or -)	509,360	175,095	165,434	24,052	873,941
Net Transfers, Balances, Actual (+ or -)	–	437	9,721	(10,158)	–
Spending Authority from Offsetting Collections:					
Earned					
Collected	491,484	239,369	28,579	68	759,500
Receivable from Federal Sources	(4,073)	2,985	(16,072)	–	(17,160)
Change in Unfilled Orders					
Advance Received	106,537	32,141	(7,176)	–	131,502
Without Advance from Federal Sources	(80,038)	22,877	(1,449)	–	(58,610)
Recoveries of Prior Year Obligations—Actual	47,640	39,901	14,804	8	102,353
Permanently not Available:					
Cancellations of Expired/No-Year Accounts	(25,637)	(6,694)	(4,257)	(347)	(36,935)
Pursuant to Public Law	(4,576)	(5,437)		–	(10,013)
Total Budgetary Resources	**$ 9,140,265**	**$ 7,279,106**	**$ 189,584**	**$ 38,449**	**$ 16,647,404**
Obligations Incurred:					
Direct:					
Category A	$ –	$ –	$ –	$ 1,000	$ 1,000
Category B	8,030,845	6,624,197	114,651	18,693	14,788,386
Reimbursable:					
Category B	450,081	277,504	2,513	–	730,098
Unobligated Balance:					
Balance Currently Available	528,454	359,060	48,213	392	936,119
Unobligated Balance not Available					
Other	130,885	18,345	24,207	18,364	191,801
Total Status of Budgetary Resources	**$ 9,140,265**	**$ 7,279,106**	**$ 189,584**	**$ 38,449**	**$ 16,647,404**
Obligated Balance, net as of October 1	$ 3,359,961	$ 1,468,499	$ 622,673	$ 9,728	$ 5,460,861
Obligated Balance, net end of period					
Accounts Receivable	(32,773)	(22,400)	(2,921)	–	(58,094)
Unfilled Customer Orders from Federal Sources	(37,123)	(23,445)	5,945	–	(54,623)
Undelivered Orders	2,309,188	705,941	97,272	1,276	3,113,677
Accounts Payable	1,508,311	1,036,533	86,567	1,425	2,632,836
Outlays					
Disbursements	$ 8,130,145	$ 6,607,808	$ 555,689	$ 26,715	$ 15,320,357
Collections	(598,021)	(271,510)	(21,403)	(68)	(891,002)
Less: Offsetting Receipts					3
Net Outlays	**$ 7,532,124**	**$ 6,336,298**	**$ 534,286**	**$ 26,647**	**$ 14,429,352**

National Aeronautics and Space Administration
Required Supplementary Information
Intragovernmental Transactions
September 30, 2002
(In Thousands of Dollars)

Intragovernmental Assets:

Agency	Fund Balance with Treasury	Investments	Accounts Receivable	Advances and Prepaid Expenses
Treasury	$ 6,766,494	$ 17,083	$ 32	$ –
Air Force	–	–	23,027	64
Army	–	–	8,689	–
Commerce	–	–	5,604	3,676
Navy	–	–	4,967	4,465
National Science Foundation	–	–	114	12,942
Secretary of Defense	–	–	4,749	92
Transportation	–	–	3,464	–
Other	–	–	2,898	35
Total	**$ 6,766,494**	**$ 17,083**	**$ 53,544**	**$ 21,274**

Intragovernmental Liabilities:

Agency	Accounts Payable	Closed Accounts Payable	Workers' Compensation	Liability for Deposit and Clearing Funds
Air Force	$ 54,907	$ 1,734	$ –	$ 3,628
Army	15,407	30	–	(44)
Commerce	15,518	329	–	271
Energy	14,784	10	–	324
Labor	–	–	15,715	–
Navy	19,314	452	–	190
National Science Foundation	4,430	35	–	6
Secretary of Defense	25,391	268	–	(1,198)
Treasury	9	–	–	125
Transportation	3,316	–	–	9,448
Other	28,168	14	–	(98)
Total	**$ 181,244**	**$ 2,872**	**$ 15,715**	**$ 12,652**

Agency	Advances from Others	Lease Liabilities	Accrued Funded Payroll	Custodial Liability
Air Force	$ 54,068	$ –	$ –	$ 727
Army	32,494	–	–	(305)
Commerce	82,481	–	–	225
Energy	360	–	–	40
Office of Personnel Management	–	–	13,885	–
National Space Foundation	28	–	–	178
Navy	6,720	–	–	10
Secretary of Defense	4,918	–	–	691
Transportation	1,189	–	–	150
Treasury	–	–	–	(1,227)
Veteran's Affairs	–	270	–	–
Other	4,161	–	–	411
Total	**$ 186,419**	**$ 270**	**$ 13,885**	**$ 900**

National Aeronautics and Space Administration
Required Supplementary Information
Intragovernmental Transactions
For the Fiscal Year Ended September 30, 2002
(In Thousands of Dollars)

Exchange Revenue

Agency		
Air Force	$	210,855
Army		40,094
Commerce		304,055
Energy		3,422
Environmental Protection Agency		1,320
National Space Foundation		1,780
Navy		42,015
Secretary of Defense		44,949
Transportation		12,025
Treasury		209
Interior		4,035
Agriculture		4,313
Veteran's Affairs		1,261
Other		2,019
Total	**$**	**672,352**

National Aeronautics and Space Administration
Required Supplementary Information
Intragovernmental Transactions
September 30, 2001
(In Thousands of Dollars)

Intragovernmental Assets:

Agency	Fund Balance with Treasury	Investments	Accounts Receivable	Advances and Prepaid Expenses
Treasury	$ 6,320,749	$ 16,871	$ 164	$ –
Air Force	–	–	28,805	152
Army	–	–	12,849	24
Commerce	–	–	8,023	2,692
Energy	–	–	1,371	–
General Services Administration	–	–	45	183
Interior	–	–	693	4
National Science Foundation	–	–	186	15,364
Navy	–	–	7,745	3,313
Secretary of Defense	–	–	8,042	213
Transportation	–	–	2,523	79
Other	–	–	1,531	11
Total	**$ 6,320,749**	**$ 16,871**	**$ 71,977**	**$ 22,035**

Intragovernmental Liabilities:

Agency	Accounts Payable	Closed Accounts Payable	Workers' Compensation	Liability for Deposit and Clearing Funds
Air Force	$ 45,457	$ 1,850	$ –	$ 261
Army	25,018	45	–	(581)
Commerce	16,725	314	–	174
Energy	20,157	10	–	646
General Services Administration	4,672	–	–	(60)
Interior	6,266	4	–	8
Labor	–	–	15,560	–
National Science Foundation	5,050	35		2
Navy	20,149	452	–	67
Secretary of Defense	6,283	269	–	1,433
Transportation	2,316	–	–	354
Other	8,325	10	–	(218)
Total	**$ 160,418**	**$ 2,989**	**$ 15,560**	**$ 2,086**

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

JAN 30 2003

Reply to Attn of: W

TO: A/Administrator
B/Acting Chief Financial Officer

FROM: W/Inspector General

SUBJECT: Audit of the National Aeronautics and Space Administration's Fiscal Year 2002 Financial Statements

Under the Chief Financial Officers Act of 1990, I am charged with the responsibility for ensuring that NASA's financial statements are audited in accordance with generally accepted government auditing standards. The Office of Inspector General engaged the independent certified public accounting firm PricewaterhouseCoopers LLP (PwC) to audit NASA's financial statements. The Defense Contract Audit Agency performed supporting work related to contractor-held, NASA-owned materials and property, plant and equipment.

The enclosed *Report of Independent Accountants* provides PwC's unqualified opinion on NASA's financial statements for the fiscal year ended September 30, 2002. An unqualified opinion states that the financial statements are fairly presented in all material respects and in conformity with generally accepted accounting principles.

The enclosed *Report of Independent Accountants on Internal Control* identifies two material weaknesses related to NASA's internal controls over (1) materials and property, plant and equipment, particularly that held by contractors and (2) its processes for preparing financial statements and the Performance and Accountability Report. PwC also identifies six reportable conditions in general controls over NASA's information technology architecture that processes financial applications.

In order to address identified weaknesses in the controls over materials and property, plant and equipment, PwC recommends that NASA create a senior management team as soon as possible comprised of finance, program management, legal, procurement and other personnel. In this regard, PwC recommends that NASA develop a detailed corrective action plan that addresses recommendations from this year's audit as well as those that remain open from last year's audit. PwC also recommends that NASA formalize policies and procedures and ensure that they are implemented and consistently and correctly applied within the Agency and at its contractors. Correcting the control weaknesses, particularly those concerning contractor-held property, will be a significant challenge for NASA, and we strongly endorse PwC's recommendations.

In the enclosed *Report of Independent Accountants on Compliance with Laws and Regulations*, PwC explains that due to the material weaknesses and reportable conditions identified in the internal control report, NASA's financial management system is not in compliance with the requirements of the Federal Financial Management Improvement Act. The recommendations contained in the internal control report are intended to address this issue.

In fulfilling our responsibilities under the Chief Financial Officers Act, we reviewed PwC's reports and selected working papers. Our quality control review is ongoing, but to date we have not identified any instances where PwC did not comply, in all material respects, with generally accepted government auditing standards.

Robert W Cobb

Robert W. Cobb

3 Enclosures

PRICEWATERHOUSECOOPERS

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Report of Independent Accountants

To the Inspector General of the
National Aeronautics and Space Administration:

In our opinion, the accompanying Consolidated Balance Sheet and the related Consolidated Statements of Net Cost and Changes in Net Position, Combined Statement of Budgetary Resources and Consolidated Statement of Financing present fairly, in all material respects, the financial position of the National Aeronautics and Space Administration (NASA) at September 30, 2002, and its net cost, changes in net position, budgetary resources and financing for the year then ended in conformity with accounting principles generally accepted in the United States of America. These financial statements are the responsibility of NASA's management; our responsibility is to express an opinion on these financial statements based upon our audit. We conducted our audit of these statements in accordance with auditing standards generally accepted in the United States of America; the standards applicable to financial audits contained in *Government Auditing Standards*, issued by the Comptroller General of the United States; and Office of Management and Budget (OMB) Bulletin No. 01-02, *Audit Requirements for Federal Financial Statements*. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

The management's discussion and analysis, required supplementary information, and required supplementary stewardship information are not required parts of the basic financial statements but are supplementary information required by the Federal Accounting Standards Advisory Board (FASAB) and OMB Bulletin No. 01-09, *Form and Content of Agency Financial Statements*. We have applied certain limited procedures, which consisted principally of inquiries of management regarding the methods of measurement and presentation of the supplementary information. However, we did not audit the information and express no opinion on it.

We were previously engaged to audit the accompanying financial statements as of and for the year ended September 30, 2001.

NASA did not provide us with information sufficient to support the amounts reported as obligations, expenses, property, plant, and equipment, and materials in the consolidated

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financial statements as of and for the year ended September 30, 2001. Accordingly, we were not able to satisfy ourselves as to the amounts recorded in these accounts.

As discussed in Note 1 to the financial statements, FASAB Statement No. 21, *Reporting of Errors and Changes in Accounting Principles*, requires that errors discovered in previously issued financial statements be corrected by restating the affected period. If the error occurred prior to the earliest period presented, the cumulative effect should be reported as a prior period adjustment. NASA detected certain errors during fiscal year (FY) 2002 that occurred in prior years and recorded those errors as if they had occurred in FY 2001. NASA did not determine what portion of those errors related to each respective prior year and should have been recorded as prior period adjustments, nor did they provide us with information needed to support the accuracy and the classification of the amounts. Accordingly, we were not able to satisfy ourselves as to the amounts of the errors that related to FY 2001 and those that related to years prior to FY 2001.

Because of the matters discussed in the fourth and fifth paragraphs of this report, the scope of our work was not sufficient to enable us to express, and we do not express, an opinion on the Consolidated Balance Sheet of NASA at September 30, 2001, and the Consolidated Statement of Net Cost for the year then ended.

In accordance with *Government Auditing Standards*, we have also issued a report dated January 24, 2003, on our consideration of NASA's internal control over financial reporting and a report dated January 24, 2003, on its compliance with laws and regulations. These reports, which disclose material weaknesses and other reportable conditions in internal control and non-compliance with the Federal Financial Management Improvement Act, are an integral part of an audit conducted in accordance with *Government Auditing Standards,* and should be read in conjunction with this report on the financial statements when considering the results of the audit.

PricewaterhouseCoopers LLP

Washington, D.C.
January 24, 2003

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Report of Independent Accountants on Internal Control

To the Inspector General of the
National Aeronautics and Space Administration:

We have audited the accompanying Consolidated Balance Sheet of the National Aeronautics and Space Administration (NASA) as of September 30, 2002, and the Consolidated Statements of Net Cost and Changes in Net Position, Combined Statement of Budgetary Resources and Consolidated Statement of Financing for the year then ended, and have issued our report thereon dated January 24, 2003. We conducted our audit in accordance with generally accepted auditing standards; the standards applicable to financial audits contained in *Government Auditing Standards*, issued by the Comptroller General of the United States; and Office of Management and Budget (OMB) Bulletin No. 01-02, *Audit Requirements for Federal Financial Statements*.

In planning and performing our audit, we considered NASA's internal control over financial reporting by obtaining an understanding of NASA's internal control, determined whether internal controls had been placed in operation, assessed control risk, and performed tests of controls. We limited our internal control testing to those controls necessary to achieve the objectives described in Office of Management and Budget (OMB) Bulletin No. 01-02. We did not test all internal controls relevant to operating objectives as broadly defined by the Federal Managers' Financial Integrity Act of 1982, such as those controls relevant to ensuring efficient operations. The objective of our work was not to provide assurance on internal control. Consequently, we do not provide an opinion on internal control.

Our consideration of the internal control over financial reporting would not necessarily disclose all matters in the internal control over financial reporting that might be reportable conditions. Under standards issued by the American Institute of Certified Public Accountants (AICPA), reportable conditions are matters coming to our attention relating to significant deficiencies in the design or operation of the internal control that, in our judgment, could adversely affect the agency's ability to record, process, summarize, and report financial data consistent with the assertions by management in the financial statements. Material weaknesses are reportable conditions in which the design or operation of one or more of the internal control components does not reduce to a relatively low level the risk that misstatements in amounts that would be material in relation to the financial statements being audited may occur and not be detected within a timely period by employees in the normal course of performing their assigned functions. Because of inherent limitations in internal controls, misstatements, losses, or noncompliance may nevertheless occur and not be detected. However, we noted certain matters discussed in the following paragraphs involving the internal control and its operation that we consider to be material weaknesses and a reportable condition under standards established by the AICPA and OMB Bulletin No. 01-02.

Material Weaknesses:

A. NASA Lacks Adequate Controls to Reasonably Assure that Property, Plant and Equipment and Materials Are Presented Fairly in the Financial Statements

The Property, Plant and Equipment ("PPE") and Materials accounts were reported together as a material weakness in FY 2001 due primarily to the lack of controls related to valuing the International Space Station (ISS), and valuing and classifying contractor-held property and materials, which, together with other scope limitations, led to our disclaimed opinion on the FY 2001 financial statements. As a result of the FY 2001 issues, we expanded the FY 2002 substantive testing scope for these accounts, which identified additional control deficiencies and material errors. As a result, we again expanded the scope of our substantive testing of PPE and Materials. We determined this further expansion of scope was necessary to compensate for these deficiencies in NASA's controls surrounding these two areas. We designed the expanded testing to reasonably assure the detection of material errors that NASA would need to correct so that PPE and Materials are presented fairly in the FY 2002 financial statements.

Contractor-Held Assets and Work-in-Process

NASA's PPE and Materials held by Contractors include land, buildings, structures, equipment, work-in-process, and materials. Combined, these categories comprise $10,854 million, or 31.0% of net PPE and $2,197 million, or 99.5% of net Materials, at September 30, 2002.

Federal Acquisition Regulations (FAR) require contractors to maintain detail property records for the NASA-owned, contractor-held items. Annually, contractors report aggregated PPE and Materials information to NASA using NASA Form 1018, NASA Property in the Custody of Contractors (NF 1018). NASA uses the NF 1018 reports to update its accounting records and as the basis for reporting Contractor-Held PPE and Materials balances in its financial statements. However, the NF 1018 reports are not integrated with the Agency's financial systems and as a result require substantial manual effort at year-end and result in a number of material year-end adjustments. We believe that because NF 1018 reporting is conducted once a year and occurs at year-end, Contractor-Held PPE and Materials balances are more susceptible to potential error and misstatement.

FY 2002 testing of Contractor-Held PPE and Materials identified the following deficiencies at various contractors:

- Work-In-Process. In general, there is a pervasive lack of adequate internal controls and consistency in the policies and procedures for PPE and Materials. This was especially true surrounding the internal controls for calculating and reporting Work-in-Process (WIP), whereby material errors were reported by contractors in FY 2002 (see details below).

Testing results disclosed that many of the contractors tested failed to report WIP to NASA as required, as well as contractors who reported WIP but lacked adequate policies and procedures for reporting WIP on the NF 1018. Adequate policies and procedures are essential to ensure that the value reported on the NF 1018 for any item of PPE and Materials, including WIP, accurately reflects the cost incurred to bring items included in WIP to their current levels of completion. This is a significant area of importance to NASA given the number of contractors responsible to account for NASA property and the significance of property in their possession.

NASA contractors also use various methods to report WIP because the NF 1018 reporting instructions and NASA FAR Supplement are unclear on how to calculate and report WIP. The result of which was instances of contractors not knowing how to calculate WIP or what to include and/or exclude within WIP. For example, in some instances certain contractors reported costs not yet incurred within WIP. We also noted other instances whereby contractors did not include in WIP all costs incurred to fabricate the assets.

FY 2002 testing also noted the lack of internal controls at NASA Headquarters to carry out its oversight responsibility for Contractor-Held PPE and Materials.

- Obsolete WIP and Materials. NASA lacks a formal policy and procedure to record obsolete WIP and Materials on NF 1018. During FY 2002, certain contractors classified significant WIP and Materials costs as "no longer required" (NLR) or obsolete and reported those costs on the NF 1018 as errors from prior periods. Prior to FY 2002, the contractors held these items in plant clearance (items set aside waiting for disposal). However, due to the lack of clear reporting instructions on the NF 1018 for obsolete items, the contractors were unaware that they were required by the NF 1018 or NASA FAR Supplement to classify and report these NLR WIP and Material items as obsolete to NASA at year-end. NASA Headquarters internal controls for this aspect of contractor reporting are also insufficient to detect these significant reporting errors.

- Inadequate Documentation. NASA lacks of proper documentation to support certain PPE items at various contractors, most notably WIP and Materials. During FY 2002, there were numerous instances where the support for selected test items could not be located with any ease or efficiency, resulting in a substantial number of significant adjustments to the PPE balance based upon estimates of asset values reported by the Contractors.

- Detecting and Correcting NF 1018 Errors. NASA lacks adequate internal controls and formal policies and procedures to detect and correct errors reported on the NF 1018 (1) by NASA for its contractors and (2) by the contractors for their subcontractors. There was a pervasive lack of adequate review by contractors of the WIP reported on the NF 1018, which resulted in significant reporting errors on the contractors' NF 1018's. FY 2002 testing also indicated a consistent lack of adequate contractor review of the WIP reported

by the subcontractor to the contractors for reporting to NASA. Finally, we noted that policies and procedures established by the contractor do not consistently require that contractors report errors to NASA on a timely basis. As the result of FY 2002 testing, errors were discovered on the FY 2001 NF 1018 submissions at various contractors.

- Corrective Action. During the FY 2002 audit, we found that FY 2001 recommended corrective actions at individual contractor locations were still unresolved at September 30, 2002. In addition, new corrective actions and deficiencies were identified during FY 2002.

Such deficiencies and inadequate controls described above result in NASA not being able to reduce to a relatively low level the risk that, in the normal course of performing their assigned functions, NASA's employees and its contractors would be able to identify and detect errors and misstatements material to the financial statements within a timely period. Therefore, we expanded the scope of our substantive testing of PPE and Materials considerably to compensate for these control deficiencies. We designed the expanded testing to reasonably assure the detection of material errors that NASA would need to correct so that PPE and Materials are presented fairly in the FY 2002 financial statements. FY 2001 material errors totaling a net of $2.8 billion were identified in the FY 2002 audit. Of this amount, we identified the following FY 2001 errors:

- One contractor revalued September 30, 2001 ISS capitalization resulting in NASA prior period adjustments of approximately ($1,901) million to Contractor-Held WIP and ($887) million to NASA-Held Assets in Space.

- Certain other contractors erroneously reported PPE as Materials. This resulted in a prior period balance sheet reclassification that increased PPE and decreased Materials by $2,691 million, respectively. As a result of this FY 2001 error correction, an additional prior period adjustment of $1,081 million was also recorded for the associated accumulated depreciation.

- One contractor misreported obsolete WIP and Materials resulting in prior period adjustments of $432 million.

- One contractor misreported PPE as WIP for assets delivered previously to NASA and were double counted in prior years as both Contractor-Held WIP and NASA Assets-in-Space. This resulted in an adjustment of $750 million.

- Several contractors erroneously misreported WIP in accordance with the NASA FAR Supplement, resulting in prior period adjustments of ($385) million.

- Certain other contractors reported other agency's PPE & materials totaling $344 million as NASA property on the NF 1018.

- Other contractors reported significant errors in the FY 2001 NF 1018's, totaling approximating ($130) million.

NASA's current 1018 reporting process provides no transparency into the annual activity of the most significant Contractor-Held PPE, Materials and WIP. Thus, as it currently stands, in any year it is not practical to test these accounts and gain significant audit efficiencies by testing additions and deletions throughout the year, as is ordinarily the case when testing property.

In addition, until NASA's current 1018 reporting process is modified to require more periodic filings (e.g. quarterly), interim reporting for the PPE and Materials accounts will not be timely or useful. The changes in prior and current year balances for Contractor-Held property are reported as "Changes in Funded Property" in NASA's Statement of Net Costs. Changes in Funded Property are expensed throughout the year and, when applicable, are capitalized through adjustments only at year-end. Failing to recognize capitalized costs during the year will result in NASA overstating net costs and understating Property and Materials at interim.

Unless addressed in FY 2003, the above control deficiencies and the current reporting requirements will prove to be significant impediments to the Agency's ability to successfully meet accelerated reporting deadlines in FY 2004.

NASA-Held Assets-in-Space and Work-in-Process

The NASA-Held Assets in Space and NASA Held WIP comprise $21,575 million, or 61.7%, of NASA's overall net PPE at September 30, 2002.

FY 2002 testing identified a lack of internal controls for NASA-Held Assets in Space and NASA-Held WIP as well as a lack of adequate oversight by NASA Headquarters to identify deficiencies in the design and operation of internal controls for these two asset areas. As a result of material errors identified during the FY 2002 audit, we increased substantive testing multiple times to compensate for the control deficiencies surrounding these two areas. We designed the expanded testing to reasonably assure the detection of material errors that NASA would need to correct so that PPE and Materials are presented fairly in the FY 2002 financial statements.

During FY 2002 testing, we identified the following deficiencies and errors at NASA Headquarters, which resulted in additional FY 2001 errors of ($2,151) million:

- After review of its significant contracts, we concluded that NASA failed to include certain costs as capitalized assets in the NASA-Held Assets in Space and NASA-Held WIP accounts. There is also no systematic process to analyze launch costs and other

capitalizable support costs associated with space hardware under construction. As a result, certain costs were not capitalized until detected by our FY 2002 substantive testing.

- NASA policies and procedures also do not specifically address purchasing software as part of a package of products and services (e.g., hardware, training, maintenance, data conversion, reengineering, site licenses and rights to future upgrades and enhancements). In accordance with FASAB Statement No. 10, *Accounting for Internal Use Software* ("FASAB No. 10"), capitalizable and noncapitalizable costs of the package must be properly allocated among individual elements on the basis of a reasonable estimate of their relative fair values. FY 2002 testing resulted in errors of for costs that were originally expensed but should have been capitalized in accordance with FASAB No. 10.

In summary, the internal control deficiencies at NASA Headquarters resulted in capital costs erroneously recorded as expenses in prior years being credited against FY 2002 costs of operations. The significance of these errors reported plus the required expansion of testing indicate a lack of controls at NASA Headquarters surrounding these NASA-Held Assets in Space and NASA Held WIP and indicate the impact of not having a fully integrated financial system.

Detailed results of all findings regarding individual contractors have been communicated to management directly as well as in separate reports.

FY 2001 Recommendations:

During FY 2002, NASA demonstrated some progress addressing and implementing certain FY 2001 recommendations. However, we believe the following recommendations are still open:

1. We recommended that NASA develop cost allocation policies to guide its financial and program managers in determining and documenting allocations of costs, including launch costs, to the ISS. During FY 2002, NASA management substantiated the reported value of ISS by developing cost allocation procedures for ISS for both the September 30, 2001 and 2002, balances. However, formal cost allocation policies still have not been created to formalize these ISS capitalization policies.

2. We recommended that, as NASA addresses our FY 2001 recommendations related to the ISS, the Agency should apply these same corrective action plans to other significant assets currently held in work-in-process pending the beginning of each asset's mission. As explained above, there are material errors reported in FY 2002, which led to an expansion of substantive audit testing to compensate for and overcome these reported deficiencies to obtain reasonable assurance that PPE and Materials are presented fairly in the FY 2002 financial statements.

3. We recommended the following relating to NASA's NF 1018:

a. NASA should revise the NF 1018 definitions and reporting instructions so that consumable materials are reported separately from items to be built into long-lived assets, consistent with FASAB and OMB form and content reporting requirements. The NF 1018 was not revised as recommended last year and given the results of FY 2002 testing and the imminent acceleration of financial reporting deadlines, we believe this recommendation to be even more imperative.

b. NASA should revise its NF 1018 to provide additional information that would allow NASA to conduct a more rigorous analysis of the NF 1018 reports and better enable it to provide reasonable assurance that PPE and Materials balances are properly aggregated and classified by the contractors. Specifically, the 1018 should provide information from the contractors regarding additions and deletions to construction-in-progress, materials, and work-in-process as well as transfers of assets among contractors and with NASA. NASA should also obtain detailed data supporting balances reported for materials and PPE in the NF 1018 reports and use this data to validate the contractor-submitted information. In particular, NASA should conduct an analysis of contractor data on the specific items comprising the materials balances reported by the contractors to determine the proper classification of these assets within the consolidated balance sheet.

c. NASA should ensure that the 1018 reporting instructions are clarified and updated regarding the use of estimated costs by the contractors. If the use of estimated costs is not permitted, then the reporting instructions should be updated to specifically preclude the use of estimates. If NASA determines that the use of estimated costs is appropriate for assigning values to finished equipment, then NASA should implement appropriate controls to determine the reasonableness of the contractor estimation techniques as referenced in SAS No. 57, *Auditing Accounting Estimates*. As mentioned above, insufficient revisions were implemented as recommended last year. Coupled with the results of the FY 2002 testing, this indicates that NASA still lacks controls surrounding Contractor-Held PPE and Materials and the contractor reporting process to reasonably assure the accuracy of the data reported by the contractors and that data's consistency with GAAP. As such, we believe this recommendation to be even more imperative as well.

We also recommended that NASA have regular dialogue with and increased monitoring of contractors to minimize the risk of errors on the 1018 reports. During FY 2002, NASA demonstrated progress and through monitoring of certain contracts detected material errors in the September 30, 2001 NF 1018 submissions. However, notwithstanding those efforts, based upon the results of the FY 2002 testing, NASA still lacks controls surrounding Contractor-Held PPE and Materials and the contractor reporting process to reasonably assure the accuracy of the data reported by the contractors and that data's consistency with GAAP. Consequently, we believe this recommendation to be even more imperative.

FY 2002 Recommendations:

In addition to our FY 2001 Recommendations, we identified new recommendations from FY 2002 testing. Our FY 2002 recommendations for the deficiencies cited in the narrative above are as follows:

4. We recommend that NASA create an overall detailed FY 2003 Corrective Action Plan to remedy deficiencies communicated within this report (current year deficiencies as well as those still open from FY 2001) and establish deadlines and accountability internally at NASA and at contractors to ensure all are resolved in FY 2003. As part of this plan, NASA should formalize the policies and procedures described above at all contractor locations and, where applicable, at NASA Headquarters and its Centers. Once the policies and procedures are updated and implemented to include effective internal controls, we recommend that NASA ensure that the policies and procedures are consistently and correctly applied throughout NASA.

   We also recommend that, as part of the Corrective Action Plan, NASA management prioritize all findings and recommendations identified in this report and work closely with its contractors to ensure all of the findings and recommendations are resolved in FY 2003. NASA should require its contractors to create their own individual Corrective Action Plans that identifies each contractor's respective findings and recommendations. The contractors' Corrective Action Plan should include timelines and milestones that link the findings and recommendations to the overall NASA Corrective Action Plan deadlines. Prioritizing all the findings and recommendations is a critical element if NASA management intends to resolve these deficiencies and remove impediments to meet the accelerated reporting requirements in FY 2004.

   Given the importance of resolving these issues, we recommend that NASA create a senior management team comprised of finance, program management, legal, procurement and others to address and resolve these findings and recommendations as soon as possible. Working backwards from the FY 2004 reporting deadlines, NASA should establish a detailed strategic plan that will consider all barriers to success and the correlating proposed solutions.

5. We recommend that NASA perform a comprehensive review of the NASA FAR Supplement and NF 1018 to ensure that all contractor requirements contained therein meet NASA's needs for financial statement reporting purposes and are in accordance with generally accepted accounting principles. To the extent applicable and necessary, NASA should identify and revise essential areas in the NASA FAR Supplement and NF 1018 instructions that need clarification. This would include issues from the FY 2001 recommendations that remain open in FY 2002 (see above) as well as those issues identified from FY 2002 testing, including:

a. WIP – NASA should create guidance that identifies the acceptable methods for calculating and reporting WIP. The guidance should be consistently applied by all contractors and should state at a minimum: what is required, how to calculate WIP, what is included and excluded from WIP, and how WIP should be reported.

b. Obsolescence – NASA needs to clarify the contractors' responsibilities for identifying and reporting obsolete and NLR WIP and materials.

c. Supporting Documentation – Overall, NASA should enhance its requirements to document assets transferred to/from NASA Centers and/or other contractors, including the related transfer forms (e.g., 1149, DD-250 et al…). We recommend that NASA require its Centers and contractors maintain full supporting documentation for all property and specifically for asset transfers. Full supporting documentation means including the appropriate dollar amount of the asset transferred and the formal, signed NASA or contractor authorization approving the transfer. Delivery of the asset should not be approved until NASA determines that both of these requirements are properly documented. Full supporting documentation will provide a detailed audit trail and establish proper cost support.

6. We recommend that NASA enhance its requirements to determine the adequacy of the contractor's review of the property reported on the NF 1018. The requirement should also include a provision for the contractor to review the property reported by its subcontractors on the NF 1018. During our FY 2002 testing, this deficiency mainly applied to WIP.

7. We recommend that NASA management provide comprehensive training to its Property Administrators and contractors on the following, at a minimum:

   a. Differences in property accounting (NASA FAR Supplement and NF 1018 requirements) and financial reporting requirements (GAAP); and,
   b. NF 1018 findings and recommendations in the current and prior years.

   We recognize that NASA may have provided this training in prior years; however, given the prevalence and significance of the errors in FY 2002 as well as the amount of substantive testing required to compensate for these errors and identified deficiencies, we recommend that NASA management provide this training with a focus on the deficiencies identified in FY 2002, as well as those still open from FY 2001.

8. We recommend that NASA ensure that all of its contractors have formal policies and procedures to detect and correct errors reported on the NF 1018. The policies and procedures should include a provision that requires the contractors to report Property correctly to NASA. If and/or when errors are detected, the policy should state that the contractors must communicate the issue to NASA on a timely basis (e.g., within one month of identification).

9. We recommend that NASA Headquarters strengthen its internal controls to improve its oversight responsibility for: (a) contractor-held PPE, (b) materials, (c) NASA-held assets in space, and (d) NASA-held WIP.

   For example, NASA Headquarters should:
   - Conduct staff training
   - Establish internal checklists to be completed each reporting period going forward (e.g., quarterly) detailing required procedures to be performed while reviewing the assets
   - To the extent applicable, formalize and update policies and procedures quarterly
   - Establish an internal action plan that requires periodic reviews of (a) key contractors' NF 1018s and (b) critical policies and procedures (e.g., reporting of WIP) on a rotational basis.

10. We recommend that NASA create formal policies and procedures to ensure all appropriate costs are capitalized as part of NASA-Held Assets in Space and NASA-Held WIP accounts. We also recommend that NASA strengthen its internal controls surrounding these two account areas to reflect these changes, including a systematic process to analyze launch costs and other capitalizable support costs associated with space hardware under construction.

11. We recommend that NASA enhance its current policies and procedures to specifically address purchasing software as part of a package of products and services (e.g., hardware, training, maintenance, data conversion, reengineering, site licenses and rights to future upgrades and enhancements). NASA must properly allocate capitalizable and noncapitalizable costs and document the commensurate support for each. We also recommend that NASA strengthen its internal controls surrounding this area to reflect these changes.

12. We recommend that NASA modify its NF 1018 reporting requirements for its contractors as soon as possible in FY 2003 to require more periodic and timely submissions (e.g., quarterly). Given the number of NASA contractors, we understand that this will be a significant undertaking because it will involve regulatory, contractual, funding, and business process changes at NASA and its contractors. These changes will directly impact NASA's ability to process these critical modifications next year.

    NASA must modify and update its own internal controls and policies and procedures in addition to those at all of their contractors to accommodate the accelerated financial statement reporting date. Therefore, we recommend that NASA proactively identify the policies, procedures, and internal controls that will be impacted by the OMB accelerated reporting due date and ensure that such policies, procedures, and internal controls are included in the Corrective Action Plan.

If all NASA's reporting requirements are not immediately resolved in FY 2003, we believe this will be the largest impediment to the Agency's ability to meet FY 2004 accelerated reporting deadlines. Until NASA's current NF 1018 reporting process is modified and the above changes have been fully implemented and resolved, we recommend that NASA disclose in all future interim report filings that its interim financial statements are materially misstated because contractor property is only reported annually and certain capital expenditures are reported as expenses.

B. NASA's Processes for Preparing Its Financial Statements and Performance and Accountability Report Need Improvement

Our testing of NASA's compilation of its financial statements identified a material weakness in NASA's process for preparing its financial statements and performance and accountability report. This material weakness was not reported on in NASA's FMFIA report. Significant errors uncovered included the following:

- Errors were made in recording significant adjustments to the financial statements, and some material adjustments that were supposed to have been recorded were not.

- One of the versions of the Statement of Net Position and the Statement of Financing included a material error representing a GAAP and OMB Bulletin 01-09 departure. NASA included as part of these statements a prior period adjustment that, per NASA, reflected the impact of the restatement performed on their FY 2001 financial statements. NASA misinterpreted available guidance and believed that since a restatement was performed in the prior year, a prior period adjustment was required during the current year to reflect the change in beginning cumulative results of operations.

- The original version of the Combined Statement of Budgetary Resources contained the line item "Total Budgetary Resources" that did not agree to the line item "Status of Budgetary Resources." Failure of these two items to reconcile exactly indicated a high likelihood of error in this statement.

- The original version of NASA's Consolidated Statement of Financing omitted the following line items: budgetary offsetting collections and receipts that do not affect net cost of operations-other; and resources that finance the acquisition of assets.

We also noted significant departures from the requirements of OMB Bulletin 01-09 in drafts of the management's discussion and analysis ("MD&A") and required supplementary stewardship information ("RSSI") on investments in research and development that NASA had provided to us.

NASA corrected all significant errors and departures from Bulletin 01-09 prior to the release of the final FY 2002 Financial Statements. However, these errors and departures should have been identified and corrected by NASA management during its internal quality control review of this information. We believe these errors are indicative of material weaknesses in NASA's controls over the compilation of its financial statements, MD&A and RSSI. These weaknesses appear to result from a combination of one or more of the following: (1) insufficient resources to address the volume of compilation work, (2) lack of an integrated financial management system, (3) lack of understanding by NASA staff of new federal reporting requirements, and (4) lack of quality controls over financial reporting, including preparation of the MD&A and RSSI.

Once fully implemented in FY 2004, NASA's Integrated Financial Management Program ("IFMP") is expected to relieve some of the workload associated with compiling the annual financial statements (e.g., it will no longer be necessary to consolidate data from 10 different financial systems). Regardless, other improvements in NASA's financial reporting process are necessary as well to help assure the Agency can prepare reliable annual and unaudited interim financial statements within accelerated deadlines in FY 2004.

Recommendations:

- We recommend that NASA improve its financial reporting internal quality review procedures to reasonably assure that information presented on the financial statements, footnote disclosures, MD&A, and RSSI are accurate and are consistent with the requirements of OMB Bulletin 01-09. To ensure the accuracy and completeness of work performed, supervisory reviews should be guided by preparation of standard checklists, such as that included in the General Accounting Office's *Financial Audit Manual* and additional technical training for staff.

- We recommend that analytical procedures be completed to ensure logical relationships exist between various financial statement amounts, and that the relationships between the different statements and line items within each statement are appropriate. Variances from expected results should be thoroughly researched and resolved. Consistent use of standard checklists can also ensure these procedures are applied.

- We recommend that NASA follow up its investment in IFMP with an investment in training and tools to support the preparation of reliable interim and year-end financial statements, MD&A, and RSSI that meets OMB form and content requirements.

- We recommend that senior NASA financial management devise a NASA-wide detailed timeline with specific milestones to ensure ample time and resources are available to complete the following tasks associated with preparing the financial statements and other

elements of the performance and accountability report: (1) data collection; (2) data validation; (3) data compilation; (4) detailed quality review.

Reportable Condition:

During FY 2002, we noted a reportable condition with regard to the general controls environment over NASA's IT architecture that process financial applications. Specifically, we identified the following deficiencies related to this area:

- Lack of Comprehensive Disaster Recovery Test of Logical Partitions that Process Significant Financial Applications - This issue was noted as a Reportable Condition in our FY 2001 internal controls report. While the NASA Automated Data Processing Consolidation Center ("NACC") has developed a test schedule to test all logical partitions within a period of one year, a test to execute such a plan has not been completed. As a result, NACC has limited assurance that, in the event of a disaster, all logical partitions that support the financially significant applications can be restored simultaneously.

- Inadequate Logical Access Controls over Security of Financial Management Systems - This issue was noted as a Reportable Condition in our FY 2001 internal controls report. While NACC has taken corrective measures to resolve the logical weaknesses noted in our FY 2001 report, we continued to note additional weaknesses in the IT architecture supporting the financially significant applications based on incremental testing performed in FY 2002. In addition, NASA Procedures and Guidelines document, NPG 2810.1, dated August 26, 1999, was noted as not being in compliance with Federal mandated security and business practice standards as prescribed within OMB Circular No. A-130 (Management of Federal Information Resources), Appendix 3.

- NASA Automated Data Processing Consolidation Center (NACC) Emergency Fire-Call Identification Practice and Revocation Process of Systems Programmer Emergency Access Privileges Can Be Enhanced - Our testing as part of the FY 2002 audit revealed weaknesses in the process to assign and revoke emergency access privileges. This issue was noted as a Management Letter Comment in FY 2001. Although NACC is taking steps to resolve this issue, we are elevating the status of this issue to a Reportable Condition in FY 2002 given that the emergency identifications with powerful privileges are available to the System Programmers at all times. In addition, we did not evidence any "concrete" corrective action plan that was being considered to implement an automated emergency fire-call ID process.

- Inappropriate User Access to Security Software Super User Capabilities Over the Logical Partitions Supporting the MSFC and KSC Financial Data - In the absence of adequate controls that restrict access to such powerful privileges, there is a risk that unauthorized activity by security administrators on these logical partitions could go undetected.

- Change Control Procedures for the STARS Application at KSC Need Enhancement - Our testing revealed deficiencies in the KSC's change control procedures for the STARS production application environment supporting the need for improvement of existing change control practices and procedures.

- Inappropriate "Write" (Update) Access to Financial Production Data for KSC and MSFC - Inappropriate access such as this could compromise the KSC and MSFC financial data in the production environment. During FY 2002, we noted several instances of inappropriate and unnecessary update access to KSC and MSFC production financial system data.

We have included a detailed discussion of the findings and related recommendations in the "Reportable Conditions" section of the FY 2002 IT management letter.

* * *

In addition, we considered NASA's internal control over required supplementary stewardship information by obtaining an understanding of NASA's internal control, determined whether these internal controls had been placed in operation, assessed control risk, and performed tests of controls as required by OMB Bulletin No. 01-02 and not to provide assurance on these internal controls; accordingly, we do not provide an opinion on such controls.

Finally, with respect to internal controls related to performance measures reported in the FY 2002 Performance and Accountability Report, Management's Discussion and Analysis - Highlights of Performance Goals and Results, we obtained an understanding of the design of significant internal controls relating to the existence and completeness assertions, as required by OMB Bulletin No. 01-02, *Audit Requirements for Federal Financial Statements*. Our procedures were not designed to provide assurance on internal control over reported performance measures; accordingly, we do not provide an opinion on such controls.

We also noted certain other matters involving internal controls that we will report to NASA management in a separate management letter.

This report is intended solely for the information and use of NASA OIG, NASA management, OMB, and Congress, and is not intended to be and should not be used by anyone other than these specified parties.

PricewaterhouseCoopers LLP

Washington, D.C.
January 24, 2003

PRICEWATERHOUSECOOPERS

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Report of Independent Accountants on Compliance with Laws and Regulations

To the Inspector General of the
National Aeronautics and Space Administration:

We have audited the accompanying consolidated balance sheet of the National Aeronautics and Space Administration (NASA) as of September 30, 2002, and the related Consolidated Statements of Net Cost and Changes in Net Position, Combined Statement of Budgetary Resources and Consolidated Statement of Financing for the year then ended and have issued our report thereon dated January 24, 2003. We conducted our audit in accordance with generally accepted auditing standards; the standards applicable to financial audits contained in *Government Auditing Standards*, issued by the Comptroller General of the United States; and, Office of Management and Budget (OMB) Bulletin No. 01-02, *Audit Requirements for Federal Financial Statements*.

The management of NASA is responsible for complying with laws and regulations applicable to the agency. As part of obtaining reasonable assurance about whether the agency's financial statements are free of material misstatement, we performed tests of its compliance with certain provisions of laws and regulations, noncompliance with which could have a direct and material effect on the determination of financial statement amounts, and certain other laws and regulations specified in OMB Bulletin No. 01-02, *Audit Requirements for Federal Financial Statements,* including the requirements referred to in the Federal Financial Management Improvement Act (FFMIA) of 1996. We limited our tests of compliance to these provisions, and we did not test compliance with all laws and regulations applicable to NASA.

Under FFMIA, we are required to report whether the agency's financial management systems substantially comply with the Federal financial management systems requirements, applicable Federal accounting standards, and the United States Government Standard General Ledger at the transaction level. To meet this requirement, we performed tests of compliance with FFMIA section 803(a) requirements. The results of our tests disclosed instances, described below, where NASA's financial management systems did not substantially comply with Federal financial management systems requirements and applicable Federal accounting standards.

We reported that NASA has material weaknesses related to (1) internal controls surrounding Property, Plant and Equipment and Materials as well as (2) its processes for preparing its Financial Statements and Performance and Accountability Report. In addition, we noted a reportable condition with regard to the general controls environment over NASA's IT architecture that process financial applications. We believe that these matters, taken together, represent substantial noncompliance with the Federal financial management systems

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requirements under FFMIA. Further details on these findings, together with our recommendations for corrective action have been reported separately to NASA in our report on internal control dated January 24, 2003.

We believe that NASA should assign priority to corrective actions for these FFMIA related matters consistent with the requirements of OMB Circular No. A-50, revised, on audit follow-up.

The results of our tests of compliance disclosed no other instances of noncompliance with laws and regulations that are required to be reported under *Government Auditing Standards* or OMB Bulletin No. 01-02.

The objective of our audit of the financial statements was not to provide an opinion on overall compliance with such provisions of laws and regulations and, accordingly, we do not express such an opinion.

This report is intended solely for the information and use of NASA OIG, NASA management, OMB, and Congress, and is not intended to be and should not be used by anyone other than these specified parties.

PricewaterhouseCoopers LLP

Washington, D.C.
January 24, 2003

NASA Office of Inspector General Summary of Serious Management Challenges

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

Reply to Attn of: W

December 23, 2002

TO: A/Administrator

FROM: W/Inspector General

SUBJECT: Most Serious Management and Performance Challenges

These are our views, pursuant to the Reports Consolidation Act of 2000, of NASA's most serious management and performance challenges. These challenges do not include perennial and ubiquitous challenges such as safety and procurement, but instead focus on temporal problems that we believe can be managed to a significantly improved status. These challenges are well known by NASA management and are critical to: ensuring a safe, efficient, and effective aeronautics and space program; preparing for and supporting important budget decisions; and ensuring Federal funds are well spent. The six challenges we identified are listed below and summarized in the enclosure.

- Restoring confidence in the management of the International Space Station and achieving U. S. Core Complete.
- Obtaining the personnel authorities and tools needed to sustain a workforce that can accomplish the NASA mission now and in the future.
- Deploying the new, integrated financial management system to improve NASA's ability to allocate costs to programs, efficiently provide reliable information to management, and support compliance with the Chief Financial Officers Act.
- Designing and implementing new internal controls to provide assurance as to the status, utility, and value of NASA-owned, contractor-held property.
- Continuing efforts to enhance information technology security by addressing known weaknesses in network security plans, measures, and internal controls.
- Ensuring that NASA's facilities are efficiently dedicated to fulfillment of NASA's mission.

If you have any questions, or need additional information, please feel free to call me at 358-1220.

Robert W Cobb

Robert W. Cobb

Enclosure

NASA's Most Serious Management and Performance Challenges

Restoring confidence in the management of the International Space Station (ISS) and achieving U.S. Core Complete.

The NASA OIG and the General Accounting Office (GAO) have found various weaknesses related to financial and cost management of the ISS. The Agency is taking positive steps to address cost growth, cost estimating, and program management and has developed success criteria for restoring confidence in NASA's ability to manage the ISS program. The top-level criteria include (1) safe and successful execution of U.S. Core Complete on budget and schedule, within the constraints that NASA can manage; (2) maximizing the allocation of program resources to the research agenda consistent with operational constraints; and (3) credible requirements, cost estimates, and analysis supporting expanded research potential after U.S. Core Complete. NASA has made progress in dealing with cost and program management concerns by appointing a Deputy Associate Administrator for ISS, who is responsible for safety, budget, performance, and schedule requirements for the ISS and Space Shuttle programs. Successful implementation and subsequent evaluation of the criteria components are fundamental to managing the ISS program effectively.

Obtaining the personnel authorities and tools needed to sustain a work force that can accomplish the NASA mission now and in the future.

NASA is undertaking initiatives to reshape and strengthen its work force, including developing a strategic human capital plan and Agency-wide work force planning and analysis system. These internal planning and analytic controls are not yet fully implemented. Additionally, NASA has proposed legislation aimed at providing the Agency with tools and authorities to facilitate efforts in recruiting and retaining skilled personnel and to reshape its work force. Further, Federal work force improvement provisions in the Homeland Security Act of 2002 will offer supplementary human capital authorities to NASA. Here again, valuable enhancements to management's controls and flexibilities await implementation and subsequent evaluation.

The OIG also has found indicators of human capital weaknesses in areas such as physical security and information technology security (ITS). Recent and ongoing OIG inspection activities continue to identify problems particularly in the area of training for information technology and procurement personnel. Although recent and planned NASA actions have been praised by both the GAO and Office of Management and Budget, reviews and evaluations by those two organizations and our findings indicate that the Agency faces key human capital challenges requiring ongoing focus and creativity. NASA managers apparently are having difficulty in hiring personnel with the experience needed to address the program weaknesses in these areas. Continued attention to implementing appropriate controls, particularly planning and analytic controls, will mitigate the NASA human capital dilemma over time.

Deploying the new, integrated financial management (IFM) system to improve NASA's ability to allocate costs to programs, efficiently provide reliable information to management, and support compliance with the Chief Financial Officers Act.

NASA's effort to deploy the Core Financial Module of its IFM Program has been underway since October 2002, and it is scheduled to be in place at all NASA Centers by June 2003. NASA's successful implementation of the Core Financial Module will require management attention because much data remains to be converted from the legacy systems to the new system. In addition, NASA does not plan to perform parallel processing of the legacy financial systems at the Centers after the Core Financial Module is implemented, and the Agency did not test all possible financial events before initial implementation of the module at two Centers.

Until both the Core Financial Module and the IFM Program Budget Formulation Module (scheduled for completion in February 2004) are fully implemented, NASA will continue to use inefficient and sometimes ineffective procedures to account for its programs, provide information to managers, and support the Agency's financial statement audit. The lack of an integrated system continues to cause significant challenges and requires substantial resources since information from 10 separate systems must be consolidated through cumbersome techniques. These outdated systems do not efficiently provide complete, timely, reliable, and consistent financial information for Agency decision-makers. The inability of NASA's financial systems to provide adequate, supporting information was a key factor resulting in the independent public accountant's disclaimer of opinion on the fiscal year (FY) 2001 financial statements and is requiring NASA management to expend considerable resources to support the FY 2002 audit.

Designing and implementing new internal controls to provide assurance as to the status, utility, and value of NASA-owned, contractor-held property.

NASA continues to have inadequate control over the contractor-held property, plant, and equipment information reported by its contractors. NASA's independent public accountant (IPA) will report the lack of adequate controls over contractor-held property as a repeat material weakness in the FY 2002 financial statements. For example, the IPA will request NASA to upwardly adjust by about $3.8 billion the FY 2001 ISS capitalization base because the contractor did not identify and report to NASA all the costs related to ISS. Also, NASA will have to record a significant upward adjustment to property from materials based on the IPA review of Space Shuttle property, which was incorrectly classified and reported on the "NASA Property in the Custody of Contractors" form (NASA Form 1018) for FY 2001. Lastly, about $700 million of obsolete materials have been identified by the Defense Contract Audit Agency in support of the FY 2002 financial statement audit. These materials should have been removed from the contractor's inventory and not reported on the NASA Form 1018.

Continuing efforts to enhance ITS by addressing known weaknesses in network security plans, measures, and internal controls.

As in prior years, the OIG identified individuals who breach NASA's ITS and serious policy and procedure deficiencies in the Agency's ITS program. For example, we found that some Center personnel had not adequately reviewed their installations' ITS plans and had incorrectly reported approval of the plans. We also found that network security measures, such as firewall rules, were not in accordance with NASA guidelines. The Agency's own penetration testing initiative identified deficient policies and ineffective enforcement of network security requirements. The independent public accountant responsible for NASA's FY 2002 financial statement audit has also identified similar ITS weaknesses during its activities, including problems identified in the FY 2001 audit but not corrected.

Management recently implemented several ITS improvements and has more initiatives planned that may significantly enhance NASA's ITS posture. For example, individuals newly appointed to leadership positions in the Office of the Chief Information Officer are now focused on improving ITS through SmartCard technology and the integration of disparate components of NASA's information technology structure.

Ensuring that NASA's facilities are efficiently dedicated to fulfillment of NASA's mission.

NASA owns over 5,400 buildings and other structures and over 100,000 acres of land. Many NASA facilities are aging, and funding has not been sufficient to keep them in good repair. To address these issues, NASA formed a Facilities Tiger Team. The Team determined that the current condition of NASA facilities is poor and deteriorating and that the current process for funding facility construction, maintenance, and repair needs improvement. The Team recommended several initiatives to improve the funding process for facilities management. The Team also recommended that an analysis be performed to compare NASA program and mission requirements to existing real property to identify opportunities for consolidations, facility disposals, and other facility uses. Implementation of the Team's recommendations is an important step in ensuring that adequate facilities exist to meet Agency needs.

Other Agency-Specific Statutorily Required Reports

Inspector General Act Amendment Reports

The Inspector General Act (as amended) requires semiannual reporting on IG audits and related activities as well as Agency followup. The following is the report on Agency followup. As required by Section 106 of the IG Act Amendments (P.L. 100-504), it includes statistics on audit reports with disallowed costs and recommendations that funds be put to better use for FY 2002. It also provides information on the status of audit and inspection reports that were pending final action as of September 30, 2002. For the last four years, NASA has included its management report annually in the Agency's Performance and Accountability report. This was done under a pilot program established by the Government Performance and Results Act (GPRA). Now that the pilot program is over, NASA will continue this practice as recommended in the Reports Consolidation Act or 2000.

AUDIT FOLLOWUP

Audit followup is a high priority for NASA. In May 2002, the Agency's Internal Control Council found that open recommendations of the OIG were a potentially major vulnerability because the number of open recommendations was becoming difficult to manage. In September, the NASA Administrator designated the Deputy Administrator as the Agency's Audit Followup Official, responsible for ensuring that corrective actions are taken on audit and inspection recommendations and that disagreements are resolved. The Audit Followup Official has made a personal commitment to resolving and closing recommendations promptly.

In addition to senior management's significant attention to open OIG recommendations, all levels of management are cooperating with the OIG to coordinate better on audit followup. As a result, we have reduced the number of open OIG recommendations by 42 percent since January 2002. This dramatic reduction follows several years of increases. Management expects further reductions in the coming months.

Over the last year, the Management Assessment Division of NASA's Office of Management Systems has taken positive steps to improve communication with the OIG throughout the audit cycle, to improve the audit/inspection report process, and to reconcile audit-tracking data with the OIG. We also streamlined management's audit resolution process to enable more efficient decisions on unresolved recommendations. NASA is transitioning our corrective action tracking system to a Web-based architecture. The new system, scheduled to be operational in early 2003, will provide e-mail notification alerts to assist in audit followup, as well as enhanced reporting and analysis capabilities.

AUDIT REPORTS WITH DISALLOWED COSTS AND RECOMMENDATIONS

Statistical Table on Audit Reports With Disallowed Costs
October 1, 2001 Through September 30, 2002

	Number of Audit Reports	Dollar Value
A. Audit reports with management decisions on which final action had not been taken at the beginning of the reporting period	0	$0
B. Audit reports on which management decisions were made during the reporting period	1	$0
C. Total audit reports pending final action during the reporting period (total of A + B)	1	$0
D. Audit reports on which final action was taken during the reporting period		
1 Value of disallowed costs collected by management	0	$0
2 Value of costs disallowed by management	1	$0
3 Total (lines D1 + D2)	1	$0
E. Audit reports needing final action at the end of the reporting period (C - D3)	0	$0

Statistical Table on Audit Reports With Recommendations That Funds Be Put to Better Use October 1, 2001 Through September 30, 2002		
	Number of Audit Reports	Dollar Value
A. Audit reports with management decisions on which final action had not been taken at the beginning of the reporting period	1	$4,000
B. Audit reports on which management decisions were made during the reporting period	2	$1,669,750
C. Total audit reports pending final action during the reporting period (total of A + B)	3	$1,673,750
D. Audit reports on which final action was taken during the reporting period		
1 Value of recommendations implemented	3	$1,673,750
2 Value of recommendations that management concluded should not or could not be implemented	0	$0
3 Total (lines D1 + D2)	3	$1,673,750
E. Audit reports needing final action at the end of the reporting period (C - D3)	0	$0

AUDIT AND INSPECTION REPORTS PENDING FINAL ACTION

Audit Reports

Report No. **Report Date**

IG-98-030 09/14/98
Single Source Suppliers of Critical Items
The OIG made three recommendations; management concurred with all. One recommendation remains open pending issuance of NASA Procedure and Guideline (NPG) 7120.5B, which is anticipated by 12/31/02.

IG-98-041 09/30/98
CNMOS Cost Savings
This audit resulted in one recommendation, which is resolved and open. An OIG investigation is in progress to determine any possible dollar savings. The OIG estimates that the investigation will be completed by 12/31/02.

IG-99-001 11/03/98
X-33 Funding Issues
The OIG made two recommendations; both are resolved and open. Management is working with the OIG to close these recommendations by 11/29/02.

IG-99-009 03/09/99
Space Station Contingency Planning for International Partners
The audit resulted in two recommendations. A meeting was held with the Audit Followup Official on 9/30/02 to discuss these unresolved recommendations. Management and the OIG are working to resolve and close both recommendations.

Report No. **Report Date**

IG-99-016 03/24/99
Advanced X-ray Astrophysics Facility
The OIG made two recommendations. Both remain open pending issuance of NPG 7120.5B, which is anticipated by 12/31/02.

IG-99-020 03/31/99
NASA Control of Export-Controlled Technologies
This audit resulted in six recommendations; one is closed. Management expects to complete corrective actions on the remaining five resolved recommendations by 10/31/02.

IG-99-047 09/22/99
Safety Considerations at Goddard Space Flight Center
The OIG made five recommendations; one remains open. Management expects to complete corrective action on this resolved recommendation by 12/31/02.

IG-99-052 09/24/99
X-33 Cost Estimating Processes
The audit resulted in four recommendations; three are closed. The remaining open recommendation was resolved during the reporting period, and management expects to complete corrective action by 12/31/02.

Report No.	Report Date

IG-00-009 02/23/00

Staffing of the Expendable Launch Vehicle Program Office at the Kennedy Space Center

Two of the OIG's four recommendations were closed upon issuance of the final report. Management anticipates completion of corrective actions on the remaining two resolved recommendations by 3/30/03.

IG-00-017 03/21/00

General Controls at Johnson Space Center's Mission Control Center

The OIG made 14 recommendations in the final report; 11 are closed. The remaining three recommendations are resolved and management expects to complete all corrective actions by 12/31/02.

IG-00-018 03/23/00

NASA Oversight of Contractor Exports of Controlled Technologies

The audit resulted in two recommendations; one is closed. Management plans to implement corrective action on the remaining resolved recommendation by 10/31/02.

IG-00-029 03/30/00

X-34 Technology Demonstrator

The OIG made 16 recommendations to management; nine have been closed. The remaining seven recommendations are resolved, and management expects to complete corrective action on all by 12/31/02.

IG-00-030 03/21/00

Compliance with the National Environmental Policy Act

This audit resulted in nine recommendations; seven are closed. Management anticipates completing corrective actions on the remaining two resolved recommendations by 10/31/02.

IG-00-034 05/12/00

Foreign National Visitors at NASA Centers

The OIG made four recommendations; one is closed. The remaining three recommendations are resolved, and management plans to implement corrective actions on all recommendations by 10/30/02.

IG-00-036 07/17/00

Summary Report on Disaster Recovery Planning Audits

The audit resulted in two recommendations to management; one is closed. Management expects to complete corrective action on the remaining resolved recommendation by 12/16/02.

Report No.	Report Date

IG-00-038 07/17/00

NASA's Organizational Structure for Implementing the Clinger-Cohen Act

The OIG made three recommendations; two are closed. Corrective action on the remaining resolved recommendation is planned for completion by 11/30/02.

IG-00-045 09/20/00

Review of NASA's Independent Cost Estimating Capability

The OIG made five recommendations; three are closed. Corrective action on the two remaining resolved recommendations is scheduled to be completed by 12/31/02.

IG-00-048 09/19/00

Contractor Exports of Controlled Technologies.

The OIG made two recommendations; they are resolved and open. Management expects to complete corrective actions on both recommendations by 10/31/02.

IG-00-055 09/28/00

System Information Technology Security Planning

The audit resulted in 10 recommendations; eight are closed. Management anticipates completing corrective action on the two remaining resolved recommendations by 1/10/03.

IG-00-057 09/28/00

NASA's Planning and Implementation for Presidential Decision Directive 63-Phase I

The OIG made three recommendations; one is closed. Management plans to implement corrective action on the remaining two resolved recommendations by 11/30/02.

IG-00-059 09/28/00

Software Assurance

This audit resulted in two recommendations; one is closed. The remaining recommendation is resolved, and management expects to complete corrective action by 12/31/02.

IG-01-003 12/21/00

Audit of Space Shuttle Payloads

This audit resulted in five recommendations; all are unresolved. A meeting was held with the Audit Followup Official on 9/30/02; management and the OIG are working towards resolution and closure of all recommendations.

IG-01-008 2/16/01

Collection of Personal Information on NASA's Publicly Accessible Web Sites

The OIG made six recommendations; two remain resolved and open. Management plans to implement corrective actions by 10/29/02.

Report No.	Report Date

IG-01-009 **03/13/01**

Faster, Better, Cheaper: Policy, Strategic Planning, and Human Resource Alignment

The OIG made five recommendations; three are closed. Management is working with the OIG to close the two remaining resolved recommendations by 10/31/02.

IG-01-018 **03/27/01**

Advanced Aeronautics Program

This audit resulted in 13 recommendations; 12 are closed. The one remaining recommendation is resolved; management anticipates completing corrective action by 10/30/02.

IG-01-021 **03/30/01**

X-37 Technology Demonstrator Project Management

The OIG made 13 recommendations; six are closed. Management anticipates completing corrective actions on the remaining seven resolved recommendations by 2/28/03.

IG-01-022 **03/30/01**

Information Technology Security

The audit resulted in four recommendations; three are open. Management plans to complete corrective actions on these resolved recommendations by 7/1/03.

IG-01-032 **08/22/01**

UNIX Operating System Security and Integrity in MCC at JSC

This audit resulted in 28 recommendations; 19 are resolved and open. Management is working with the OIG to close all remaining recommendations by 12/31/02.

IG-01-033 **08/21/01**

UNIX Operating System Security and Integrity of the New Business Systems at the JPL

The OIG made 21 recommendations; 18 are closed. Management is working with the OIG to resolve one recommendation, and anticipates completing corrective actions on all remaining open recommendations by 11/15/02.

IG-01-034 **08/31/01**

Controls Over the Use of Plastic Films, Foams, and Adhesive Tapes in and Around the Space Shuttle Orbiter Vehicles

Of the five recommendations made in the report, one remains open. It is resolved and management expects to complete corrective action by 3/15/03.

Report No.	Report Date

IG-01-036 **09/27/01**

NASA's Information Systems Processing National Security Information

The OIG made three recommendations; all are resolved and open. Management anticipates completion of corrective actions by 12/31/02.

IG-01-037 **09/27/01**

Agencywide IT Security Program for Unclassified Systems

The audit resulted in seven recommendations; five are open and resolved. Management plans to complete corrective actions on all remaining recommendations by 3/30/03.

IG-01-038 **09/27/01**

NASA's Planning and Implementation for PDD 63

The OIG made two recommendations, both of which are resolved. Management expects to complete corrective actions on both recommendations by 12/15/02.

IG-01-042 **09/28/01**

Safety of Lifting Devices and Equipment at Stennis Space Center

The OIG made 16 recommendations; one remains open. Management anticipates implementing correction action on this resolved recommendation by 11/01/02.

IG-01-043 **09/28/01**

Information Technology Security Requirements in NASA Contracts, Grants, and Cooperative Agreements

Of the three recommendations made by the OIG, one is closed. The two remaining recommendations are resolved and open. Completion of corrective action is expected by 1/30/03.

Inspection Reports

Report No.	Report Date

G-98-011 **08/27/99**

Flight Termination Systems

This review resulted in six recommendations; two are closed. The remaining four recommendations are resolved and open. Management anticipates completion of all corrective actions by 11/22/02.

G-99-006 **12/11/98**

NASA's Implementation of a Public Key Infrastructure

The OIG made seven recommendations; five are closed. Management will implement corrective action on the remaining two resolved recommendations by 3/28/03.

Report No.	Report Date

G-99-007 08/06/99
Assessment of the NASIRC
This review resulted in 11 recommendations; six are closed. Management and the OIG are working to resolve three unresolved recommendations, and close all five open recommendations by 3/28/03.

G-99-010 07/21/00
International Space Station Command and Control Communications Security
This review resulted in five recommendations; four are closed. Management anticipates completing corrective action on the remaining resolved recommendation by 10/31/02.

G-99-014 05/26/00
NASA's Badging Program and Physical Access Controls at the Wallops Flight Facility
The OIG made six recommendations in this report; five are closed. Management plans to implement corrective action on the remaining resolved recommendation by 11/30/02.

G-00-004 07/14/00
NASA's Badging Program and Physical Access Controls at the GSFC
The OIG made 17 recommendations in this report. All recommendations are resolved; 14 recommendations are closed. Management anticipates completing corrective actions on the remaining three recommendations by 12/31/02.

G-00-019 02/06/01
Information Technology Security Training and Development and other Human Resources Considerations
The OIG made seven recommendations; one is closed. Management and the OIG are working to resolve one recommendation, and close all open ones by 07/01/03.

Report No.	Report Date

G-00-021 02/20/01
Assessment of NASA's Use of the Metric System
This inspection resulted in eight recommendations; all are resolved and open. Management expects to complete corrective actions for all recommendations by 1/31/2003.

G-00-022 03/28/01
Review of the Designated Approving Authority at NASA
The OIG made seven recommendations; all are resolved and open. Management anticipates completing corrective actions for these recommendations by 11/15/02.

G-01-014 09/28/01
Langley Research Center Network Firewall
This review resulted in five recommendations; four are closed. The remaining open recommendation is resolved, and management expects to complete corrective action by 10/31/02.

G-01-019 9/28/01
Followup Review of the Independent Program Assessment Office
The OIG made nine recommendations; seven are closed. The two remaining open recommendations are unresolved. Management is working with the OIG to resolve and close both recommendations by 10/15/02.

G-01-020 07/30/01
Inspection of NASA Headquarters Employee Background Investigations Process
The OIG made 12 recommendations; 11 are closed. Completion of corrective action on the remaining resolved recommendation is planned by 12/2/02.

There are no disallowed costs or better use of funds associated with any of these audit and inspection reports.

Acronyms

Acronyms

2MASS	2-Micron All Sky Survey

A

ACE	Advanced Composition Explorer
ADP	acceptance data package, also Automated Data Processing
AGAGE	Advanced Global Atmospheric Gases Experiment
AICPA	American Institute of Certified Public Accountants
AIM	Aeronomy of Ice in the Mesosphere
ANOPP	Aircraft Noise Prediction Program
ARC	Ames Research Center
AVATAR	Advanced Vehicle Analysis Tool for Acoustics Research
AVHRR	Advanced, Very-High-Resolution Radiometer
AWIN	aviation weather information network

C

CAN	Cooperative Agreement Notice
CATS	Corrective Action Tracking System
CBS	Columbia Broadcasting System
CD	compact disk
CDC	Centers for Disease Control and Prevention
CD-ROM	Compact Disk-Read-Only Memory
CEOS	Committee on Earth Observation Satellites
CERES	Clouds and the Earth's Radiant Energy System
CFO	Chief Financial Officer
CNMOS	Consolidated Network Mission Operations Support
CONTOUR	Comet Nucleus Tour
CORE	Continuous Observations of the Rotation of the Earth
CRV	Current Replacement Value
CRYSTAL	Cirrus Regional Study of Tropical Anvils and Layers
CRYSTAL-FACE	Cirrus Regional Study of Tropical Anvils and Cirrus Layers-Florida Area Cirrus Experiment
CSRS	Civil Service Retirement System

D

DAAC	Distributed Active Archive Center
DARPA	Defense Advanced Research Projects Agency
DARWIN	Developmental Aeronautics Revolutionizing Wind tunnels and Intelligent Systems of NASA
DCAA	Defense Contract Audit Agency
DEM	Digital Elevation Models
DFRC	Dryden Flight Research Center
DM	Deferred Maintenance
DNA	deoxyribonucleic acid
DOD or DD	Department of Defense

E

EIRT	External Independent Review Team
ELV	Expendable launch vehicle
ENSO	El Niño Southern Oscillation
EO	Earth observing
EOS	Earth Observing System
EOSDIS	Earth Observing System Data Information Systems
EPA	Environmental Protection Agency
ER	Expedite the Processing of Experiments to Space Station (EXPRESS) Rack
ESDIS	Earth Science Data Information Systems
ESIP	Earth Science Information Partner
ESTO	Earth Science Technology Office
EXPRESS	Expedite the Processing of Experiments to Space Station

F

FAA	Federal Aviation Administration
FACS	financial and contractual status
FAIR	Federal Activities Inventory Reform

FAME	Full-sky Astrometric Mapping Explorer
FAR	Federal Acquisition Regulations
FASAB	Federal Accounting Standards Advisory Board
FAST	Fast Auroral Snapshot Explorer
FECA	Federal Employees' Compensation Act
FEGLI	Federal Employees Group Life Insurance
FEHB	Federal Employee Health Benefits
FERS	Federal Employees Retirement System
FFMIA	Federal Financial Management Improvement Act
FMFIA	Federal Managers' Financial Integrity Act
FRD	Flight Requirements Document
FUSE	Far Ultraviolet Spectroscopic Explorer
FY	fiscal year

G

GAAP	Generally Accepted Accounting Principles
GALEX	Galaxy Evolution Explorer
GAO	General Accounting Office
GE	General Electric
GISS	Goddard Institute for Space Studies
GLAST	Gamma-ray Large Area Space Telescope
GMI	Global Modeling Initiative
GPCP	Global Precipitation Climatology Project
GPM	Global Precipitation Measurement
GPS	Global Positioning System
GRACE	Gravity Recovery and Climate Experiment
GSFC	Goddard Space Flight Center

H

HALOE	Halogen Occultation Experiment
HBCU	Historically Black Colleges and Universities
HEDS	Human Exploration and Development of Space
HRF	Human Research Facility
HSF	Human Space Flight
HSI	Hispanic Serving Institution

I

ICAO	International Civil Aviation Organization
IceSAR	Synthetic Aperture Radar
ICESat	Ice, Cloud, and Land Elevation Satellite
ID	identification
IFM	Integrated Financial Management
IFMP	Integrated Financial Management Program
IFSAR	Intelligence Reform Interferometric Synthetic Aperture Radar
iLAB	Information Laboratory
IMAGE	Imager for Magnetopause-to-Aurora Global Exploration
InSAR	Satellite Radar Interferometry
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute [for Climate Prediction]
ISCCP	International Satellite Cloud Climatology Project
ISS	International Space Station
IT	information technology

J

JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center

K

KSC	Kennedy Space Center
KSNN	Kid's Science News Network

L

LBA-ECO	Large-Scale Atmosphere Biosphere Experiment in Amazonia
	Ecological Research Program
LCLUC	Land Cover Land Use Change
LLP	Limited Liability Partnership

LPT	Low Power Transceiver
LTMPF	Low Temperature and Microgravity Physics Facility

M

Magsat	Geomagnetic satellite
MAM-1	Microarcsecond Metrology
MD&A	Management's Discussion and Analysis
MER	Mars Exploration Rover
MIDEX	Medium-Class Explorer
MISR	Multi-angle Imaging Spectroradiometer
MIT	Massachusetts Institute of Technology
MODIS	Moderate-Resolution Imaging Spectroradiometer
MOPITT	Measurements of Pollution in the Troposphere
MOZART	Model for Ozone and Related Chemical Tracers
MSFC	Marshall Space Flight Center

N

NACC	NASA Automated Data Processing (ADP) Consolidation Center
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Center for Environmental Prediction
NEPA	National Environmental Policy Act
NESDIS	National Environmental Satellite, Data, and Information Service
NF	NASA Form
NGST	Next Generation Space Telescope
NISN	NASA Integrated Services Network
NLR	no longer required
NOAA	National Oceanic and Atmospheric Administration
NODIS	NASA Online Directives Information System
NOx	oxides of nitrogen
NPD	NASA Policy Directive
NRA	NASA Research Announcement
NSA	National Security Agency
NSIPP	NASA's Seasonal-to-Interannual Prediction Project

O

OBPR	Office of Biological and Physical Research
OCHMO	Office of the Chief Health and Medical Officer
ODIN	Outsourcing Desktop Initiative
OGCM	ocean general circulation model
OH	hydroxyl radical
OIG	Office of Inspector General
OMB	Office of Management and Budget
OPM	Office of Personnel Management
ORB	other retirement benefits
OSSE	Observing System Simulation Experiments

P

PAPAC	Provide Aerospace Products and Capabilities
PART	Performance Assessment Rating Tool
PBC	Performance Based Contract
PBS	Public Broadcasting Service
PDR	Preliminary Design Review
PIC	Procurement Information Circular
PMA	President's Management Agenda
PMAP	President's Management Action Plan
PP&E	Property, Plant, and Equipment
PwC	PricewaterhouseCoopers Limited Liability Partnership (LLP)

Q

QASP	Quality Assurance Surveillance Plan
QuikTOMS	Quick Total Ozone Mapping Spectrometer

R

R&D	Research and Development
RADARSAT	Canadian Radar Satellite

RAMM	Canadian Radar Satellite (RADARSAT) Antarctic Mapping Mission
ReMaP	Research Maximization and Prioritization Task Force
RERP	Radiobiology External Review Panel
RHESSI	Reuven Ramaty High Energy Solar Spectroscopic Imager
RNA	ribonucleic acid
RP	hydrocarbon
RSI	Required Supplementary Information
RSSI	Required Supplementary Stewardship Information
RXTE	Rossi X-ray Timing Explorer

S

SAGE	Stratospheric Aerosol and Gas Experiment
SAMPEX	Solar, Anomalous, and Magnetospheric Particle Explorer
SAS	Statement on Auditing Standards
SAT	Science, Aeronautics and Technology
SATS	Small Aircraft Transportation System
SBUV/2	Solar Backscatter Ultraviolet
SCIGN	Southern California Integrated Global Positioning System (GPS) Network
SeaDAS	Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data analysis system
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SES	Senior Executive Service
SESWG	Solid Earth Science Working Group
SF	Standard Form
SFOC	Space Flight Operations Contract
SHADOZ	Southern Hemisphere Additional Ozonesondes
SHCP	Strategic Human Capital Plan
SIM	Space Interferometry Mission
SIMBIOS	Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies
SIRTF	Space Infrared Telescope Facility
SLI	Space Launch Initiative
SLR2000	Complete Solar Laser Ranging 2000 satellite
SMEX	Small Explorers
SOFBALL	Structure of Flame Balls at Low Lewis-number
SOHO	Solar and Heliospheric Observatory
SOLAR	Site for On-line Learning and Resources
SOLVE	Stratospheric Aerosol and Gas Experiment (SAGE) III Ozone Loss and Validation Experiment
SPIE	International Society for Optical Engineering
SPIRE	Spectral and Photometric Imaging Receiver
SST	sea surface temperature
STARS	Staffing and Recruiting System
STD	Standard
STES/PCAM	Single-locker Thermal Enclosure System/Protein Crystallization Apparatus for Microgravity
STS	Space Transportation System
STTR	Small Business Technology Transfer
SWAS	Submillimeter Wave Astronomy Satellite

T

TCU	Tribal college
TDRS	Tracking and Data Relay Satellite Project
THESEO	Third European Stratospheric Experiment on Ozone
TIMED	Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics
TOMS	Total Ozone Mapping Spectrometer
TOPEX	Ocean Topography Experiment
TPF	Terrestrial Planet Finder
TRACE	Transition Region and Coronal Explorer
TRACE-P	Transport of Chemical Evolution over the Pacific
TRMM	Tropical Rainfall Measuring Mission

U

UCI	University of California, Irvine
UCLA	University of California, Los Angeles
UEET	Ultra-Efficient Engine Technologies
UF	utilization flight
URL	Uniform Resource Locator
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

V

VAMS	Virtual Airspace Modeling and Simulation
VAST	Virtual Airspace System Technology
VDL	Very high frequency (VHF) data link
VHF	Very high frequency
VLBI	Very Long Baseline Interferometry
VPP	Voluntary Protection Program

W

WINN	Weather Information Network
WIP	Work-in-Process
WMO/UNEP	World Meteorological Organization/United Nations Environment Programme
WORF	Window Observational Research Facility

X

XML	Extensible Markup Language

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