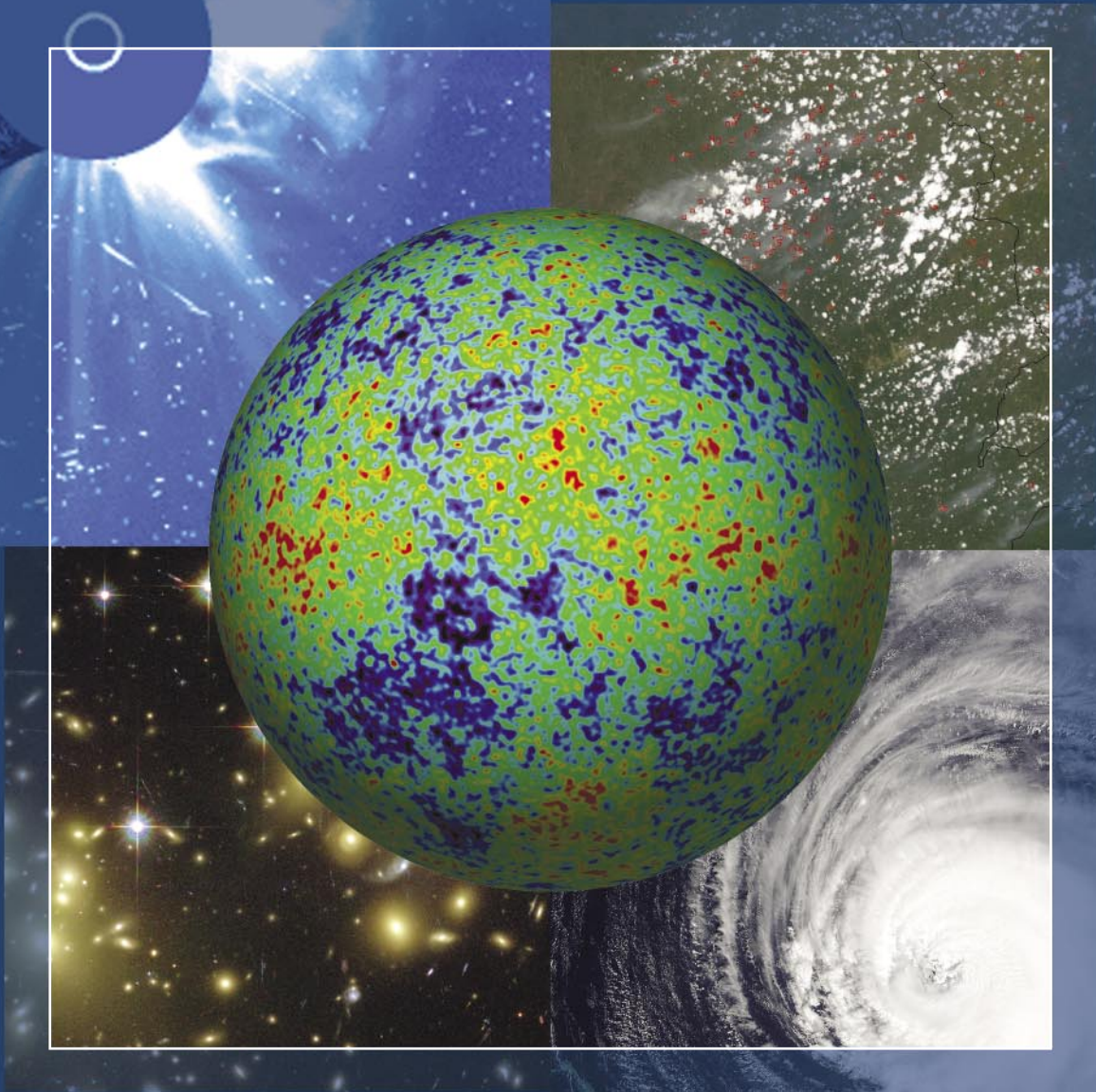


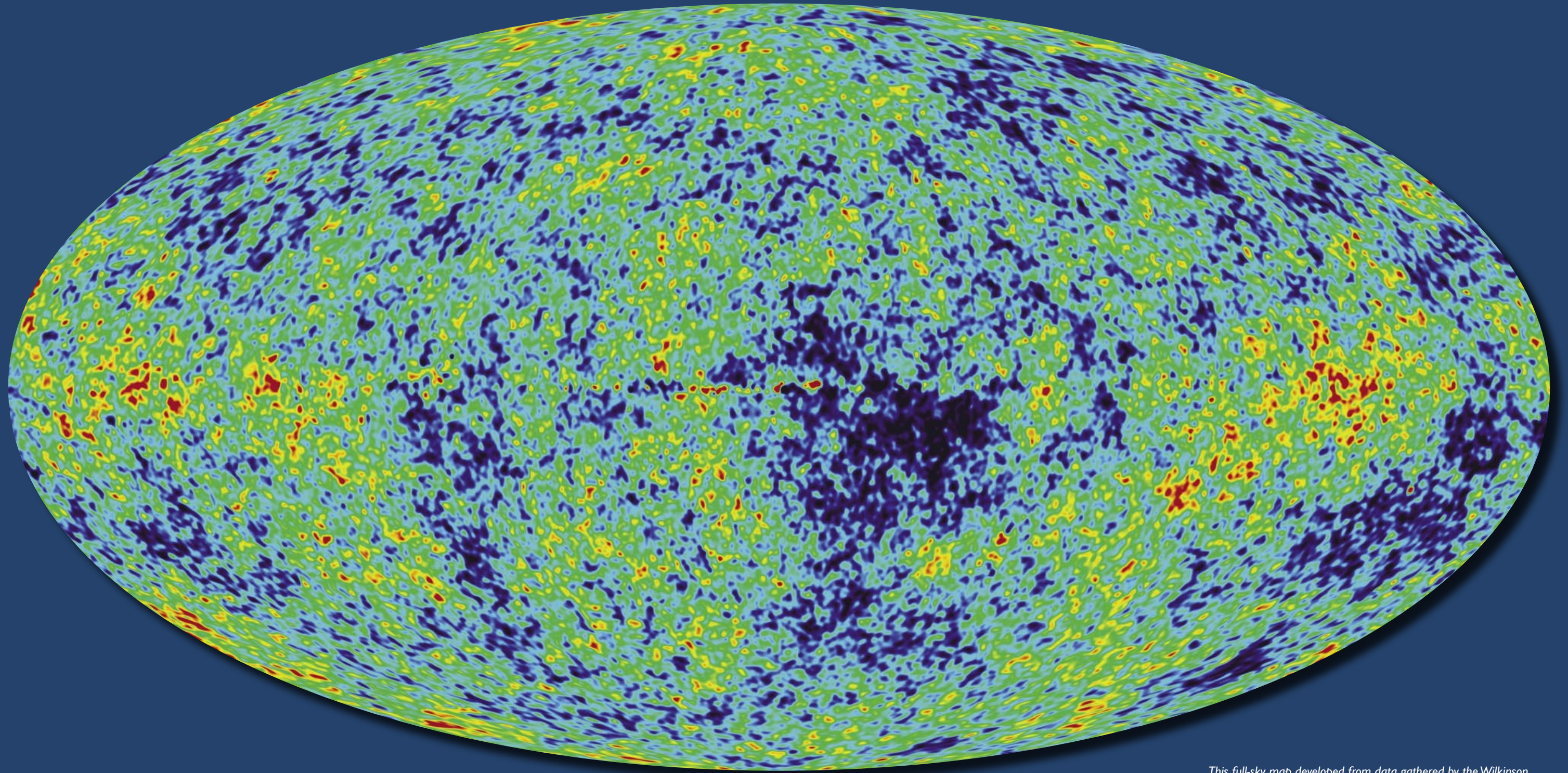
National Aeronautics and Space Administration

Goddard Space Flight Center

2003



Annual Report



This full-sky map developed from data gathered by the Wilkinson Microwave Anisotropy Probe shows the oldest light in the universe, and in essence is a “baby picture” of the cosmos. The data revealed that the first stars ignited only 200 million years after the Big Bang and pegged the age of the universe at 13.7 billion years.

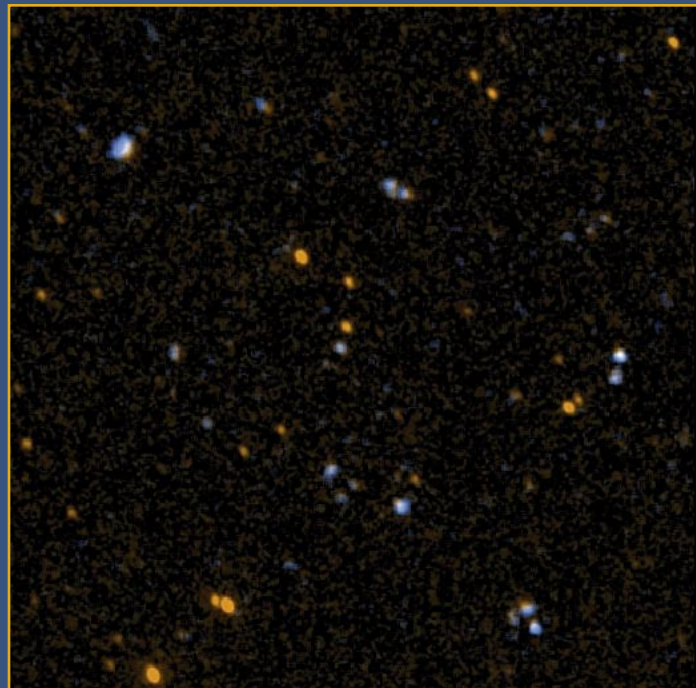
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The Stars are Watching

The Galaxy Evolution Explorer, developed as part of the Goddard Space Flight Center's 40-year-old Explorer Program, was the first spacecraft to launch following the Columbia tragedy. In

remembrance, NASA dedicated the spacecraft's "first light" images to the crew. This image shows 50 celestial objects in the constellation of Hercules. The Hercules region was directly above Columbia when it made its last contact with NASA Mission Control over the skies of Texas on February 1, 2003.



Director's Message

Dedicating Ourselves to One NASA



One year ago, residents of East Texas heard a crackling boom and within minutes pieces of debris, streaking across the sky at 12,000 miles per hour, began falling to the ground. It took only minutes for emergency personnel and others to know what these observers had witnessed — the breakup of Space Shuttle Columbia. Seventeen years after the Challenger explosion, the nation once again found itself mourning the loss of seven brave souls who had dedicated their lives to exploring the heavens so that we might live better here on Earth.

Words cannot describe the grief that we at the Goddard Space Flight Center felt upon hearing the news. We had worked with the Columbia crew. We knew these individuals personally. They had carried experiments developed and managed by Goddard personnel. Like millions of others around the globe, we mourned.

Ultimately, however, we moved on. But in the process of moving on, we must remain mindful of why Columbia disintegrated over the western United States in the first place. Although NASA enjoys a great legacy, the Agency made mistakes.

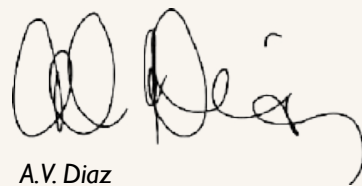
According to the Columbia Accident Investigation Board, the tragedy occurred because of a breach in the Thermal Protection System that allowed superheated air to penetrate the insulation of the left wing and progressively melt the aluminum structure. The increased aerodynamic forces, combined with the weakened structure, ultimately led to the orbiter's break up.

Just as important, however, were the organizational reasons for Columbia's sudden and profound loss. In particular, the investigative board found that NASA had begun to rely on past successes, substituting it for sound engineering practices. The board found that organizational barriers prevented NASA personnel from effectively communicating critical safety information and that professional differences of opinion often were stifled. It uncovered a lack of integrated management across the programs.

With these findings came recommendations for correcting the problems. And it is here that Goddard now focuses its energies. Although we have established a reputation for engineering and scientific excellence, in our business the margins are always slim. Therefore, it behooves us to dedicate ourselves to working as a team, to tearing down the stovepipes that discourage cooperation and communication among our NASA colleagues. In short, we must embrace the principles set forth by the "One NASA" initiative. If we do these things, we will correct the problems that contributed to the Columbia tragedy. If we do these things, NASA can truly become a great Agency.

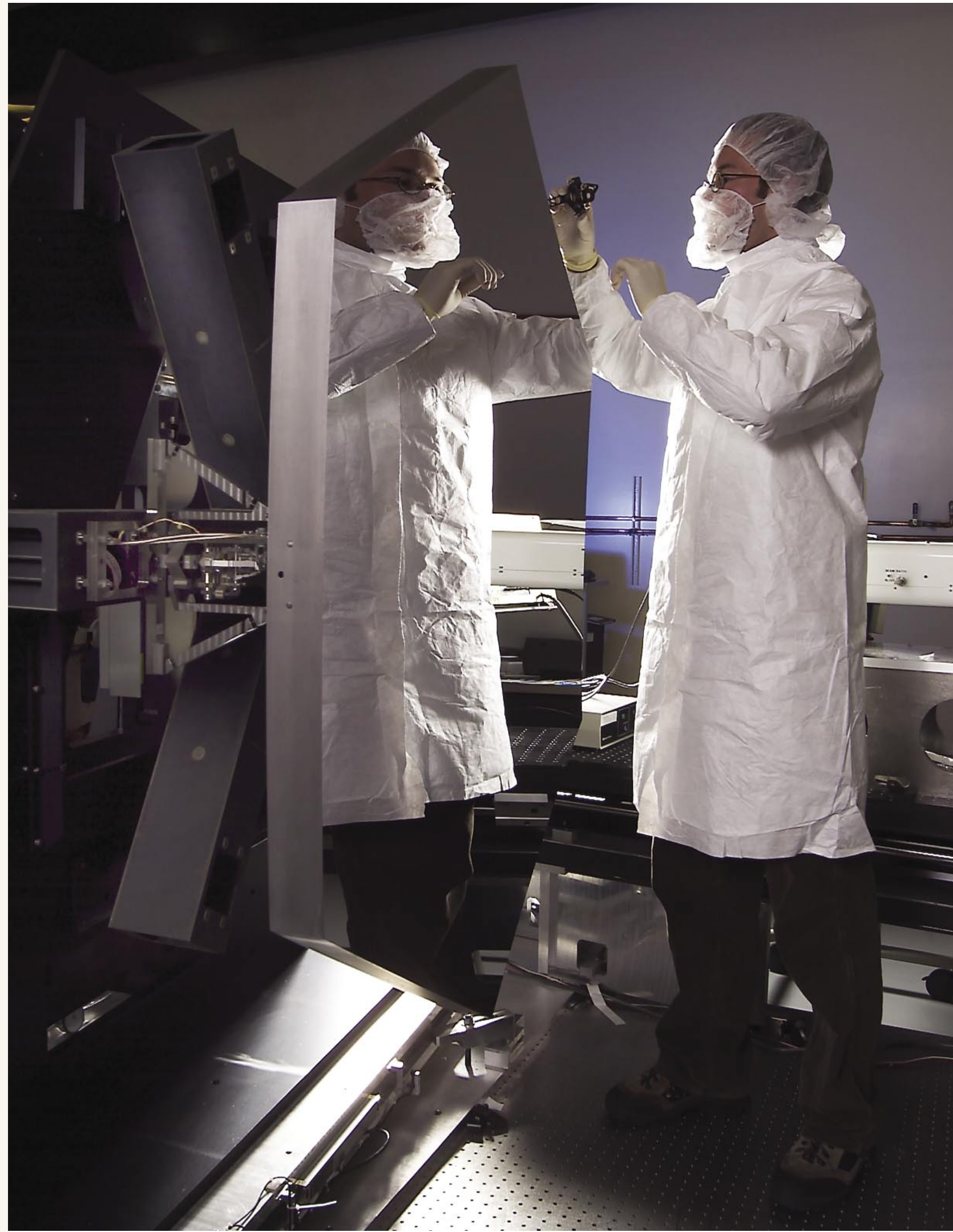
This report describes what we are doing to make sure that we accomplish our full potential. It outlines our three-part prescription for success and how this approach is leading to significant new accomplishments in space science, Earth science, and technology development.

Although we all were affected by the Columbia accident, let that incident motivate us to do better. This way, we will best serve the memories of those seven men and women who soared through space because they understood the risks, yet still believed in what they were doing.



A.V. Diaz

Following a thorough evaluation, the prime contractor on the James Webb Space Telescope, the follow-on to the Hubble Space Telescope, recommended beryllium as the primary material for the telescope's segmented 6.5-meter primary mirror. Ball Aerospace Technologies Corp. will build the mirror.





◀ Goddard engineers work on the X-ray Spectrometer, which will fly on the Japanese ASTRO-E spacecraft in February 2005. The instrument will take high-resolution measurements of celestial objects in the “soft” X-ray range.

Prescription for Success

At the heart of the Columbia Accident Investigation Board's recommendations and efforts to create a new culture at NASA are our people, our human capital. Although Federal employees ranked NASA as the best place to work in 2003, we must continuously recruit and retain the nation's best engineers, scientists, and technologists. Otherwise, NASA will not be able to effectively carry out its vision and mission of understanding and protecting our home planet, exploring the universe, and inspiring the next generation of explorers, as only NASA can.

Goddard continued to focus on three key strategies to better manage our human capital and concentrate on what is central to our future success:

- Exciting work
- Sustainable workload
- Value-centered management

In essence, this three-point approach recognizes that people make a difference. Our people need challenging work, access to state-of-the-art facilities and equipment, and a corporate culture that promotes integrity, dedication, and “respect” for the diversity of people and ideas. If we remain true to these ideals, our workforce will remain committed to NASA's mission.

Culture Survey

In 2003, Goddard learned how it was doing carrying out its three-point prescription for success.

In a Center Culture Survey, employees said that Goddard was meeting its mission goals and felt positive about the value of their role and contributions. They believed the Center was adjusting to changes and that they could balance their work and personal lives well. Employees also said that a respect for diversity existed at Goddard — findings that were particularly well received in light of the report by the Columbia Accident Investigation Board.

However, the survey revealed some weaknesses. Employees expressed concern about the Center's ability to maintain sufficient in-house work and sustain a vital workforce, which are central to maintaining our technical competencies. Resource issues, such as how management balances workload and makes resource-related decisions, received lower scores. Employees also expressed divergent perspectives on partnerships — a key strategy in the “One NASA”

Goddard Missions of 2003

Ice, Cloud, and Land Elevation Satellite

Cosmic Hot Interstellar Spectrometer Satellite

Solar Radiation and Climate Experiment

Tracking and Data Relay Satellite-J

Galaxy Evolution Explorer

initiative. Although they saw value in partnering to achieve mission goals, some employees still showed a strong inclination to tackle challenges by themselves. And last, employees ranked Goddard lower on our systems for managing risk, which raises a question about how we sustain the Center at the cutting-edge of discovery.

Although the survey revealed areas that still need improvement, which we will continue to address, Goddard was heartened by the survey results. It showed that the Center is meeting its mission commitments, making discoveries in Earth and space science, and developing new technologies that allow these discoveries. If we compete for and win exciting work, the Center's workforce is prepared and motivated to meet the challenges of NASA's mission. This is good news.

Quality of Worklife

To address worklife issues, Goddard began instituting several new programs and enhancing others to address employee concerns revealed in a separate worklife survey. The Center has beefed up its awards and recognition program and instituted a new employee referral service, which provides confidential information related to elder and dependent care, health and wellness, financial and legal services, and educational needs. Among other things, the Center also offers a more comprehensive flexible work program and is increasing employee communication and awareness programs. Lactation facilities for new mothers now operate at specific sites across campus. These initiatives are continuing as part of Goddard's Quality of Worklife program.

Capital Improvements

While addressing employee concerns remains a high priority, we also must focus our attentions on our facilities — another vital ingredient to maintaining a robust workforce. In 2003, the National Capital Planning Commission approved Goddard's Facilities Master Plan for the Greenbelt campus, representing an important step for the Center as it attempts to more fully integrate its activities.

The Wallops Flight Facility also broke ground on a new payload processing facility for NASA's science and technology missions. When finished, the building will handle the testing and processing of spacecraft and upper-stage components and the preparation of scientific balloons.

Teaming Arrangements

Getting access to state-of-the-art facilities and equipment does not always mean that we must build the resources ourselves. Teaming with NASA Centers and other organizations can give us opportunities that we might not otherwise enjoy.



In 2003, Goddard and Capitol College broke ground on the new multimillion-dollar William McGowan Academic Center, which will house a mission control room for several NASA spacecraft.

In 2003, Goddard and Capitol College broke ground on the new multimillion-dollar William McGowan Academic Center, which will house a mission control room for NASA's Earth Probe Total Ozone Mapping Spectrometer, the Upper Atmosphere Research Satellite, the Earth Radiation Budget Satellite, and the Tropical Rainfall Measuring Mission. The arrangement covers another NASA mission objective — exposing students to the excitement of science and motivating them to pursue careers in science, technology, math, and engineering.

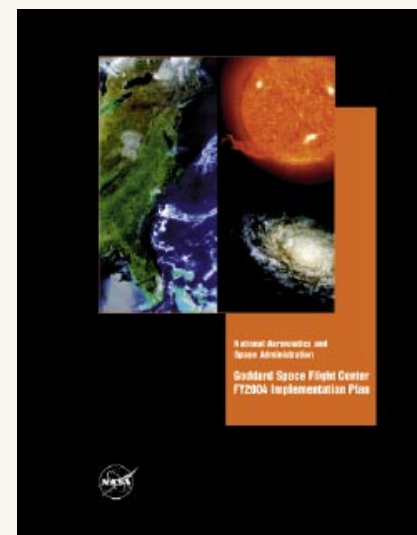
Goddard also signed a Memorandum of Understanding (MOU) with the Langley Research Center, which, among many other things, gives Goddard researchers preferred access to Langley facilities and personnel.

Center Implementation Plan and ISO Certification

Also building on our three-fold prescription for success was the publication of the FY 2004 Goddard Implementation Plan. It identifies our roles and responsibilities within NASA and the strategies we will follow.

Goddard's Quality Management System, meanwhile, sets the rules and standards that the Center will use when carrying out its responsibilities under the plan. It is an essential element of Goddard's multifaceted approach for capturing and applying best practices and lessons learned. As part of this effort, the Center maintains third-party certification by the International Organization for Standardization (ISO), an international, non-governmental developer of standards. In 2003, Goddard successfully implemented the updated ISO 9001:2000, which will help the Center more effectively carry out its implementation plan.

The FY2004 GSFC Implementation Plan



◀ Hurricane Isabel left an indelible mark on the East Coast this year, but the storm was only packing winds of 138 miles per hour, with gusts of up to 167 miles per hour, when NASA's Terra spacecraft snapped this photo.

Viewing Earth as a System

Exciting work drives employees at the Goddard Space Flight Center. Nowhere is that more evident than in the area of Earth System Science, one of six important NASA enterprises. In 2003, Goddard Earth scientists continued to make headlines in their quest to understand Earth's system and to improve their ability to predict climate changes, weather, and natural hazards.

Their discoveries, often the result of collaborative efforts with other organizations, are helping scientists worldwide to better understand the complex interaction of Earth's systems and the impact of human civilization on the environment.

Climate Change

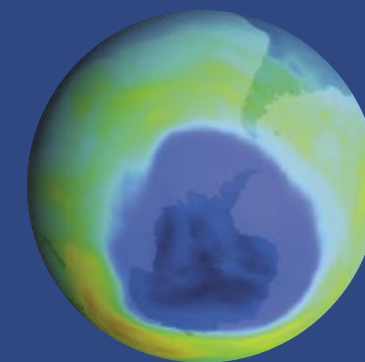
One of the fundamental questions driving Goddard's Earth science program involves variability: How is the global Earth system changing? One of the leading reports on climate change, the Intergovernmental Panel on Climate Change, suggested in 2001 that between 1990 and 2100, the world's average temperature would rise between 0.6 and 2.5 degrees Celsius or 1.1 to 4.5 degrees Fahrenheit. However, new research by the Goddard Institute for Space Studies indicates that temperatures may actually warm less than predicted.

NASA's improved global climate change model, which simulates and projects how the Earth's climate may change, shows that the oceans have absorbed heat since 1951 and would continue to do so for the next 50 years. The likely result, researchers said, is a change in regional climate patterns.

There is no question, though, that temperatures are increasing. Another NASA study released in 2003 showed that perennial sea ice in the Arctic was melting faster than previously thought — at a rate of 9 percent per decade. If these melting rates continue for a few more decades, the perennial sea ice would likely disappear entirely within this century. While melting sea ice would not affect sea levels, the researchers concluded it could profoundly affect summer shipping lanes, plankton blooms, ocean circulation systems, and global climate.

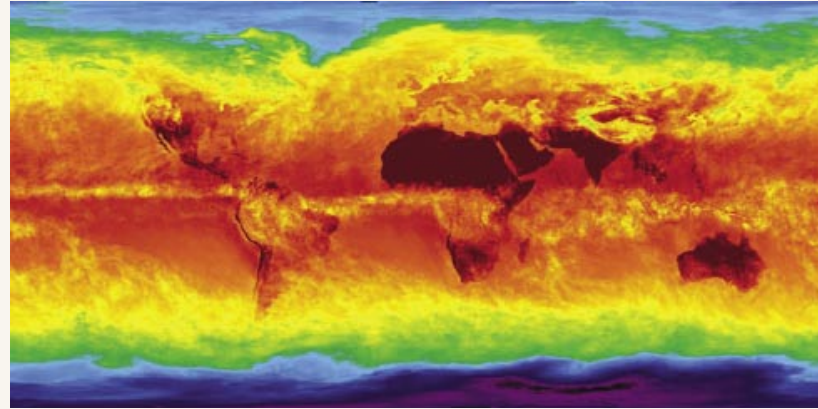
Carbon Cycle

Temperature increases also appear to be affecting plant life in the world's oceans. A Goddard researcher announced this year that phytoplankton, the tiny ocean plants that play a vital role in converting carbon dioxide into oxygen, had become less productive since the 1980s. The finding is important. Phytoplankton processes about half of the carbon dioxide from the environment through photosynthesis. Land plants pull in the other half.



The 2003 Antarctic ozone hole, as measured by the Earth Probe Total Ozone Mapping Spectrometer and the NOAA-16 Solar Backscatter Ultraviolet instrument, was the second largest ever observed. On September 11, 2003, the hole covered 10.9 million square miles, which is slightly larger than the North American continent. The largest hole, defined as a thinning of the ozone layer over the Antarctic, occurred in 2000 and covered 11.5 million square miles.

In 2003, NASA's Aqua spacecraft celebrated its first anniversary in space. In this infrared image, Aqua showed the temperature of the Earth's surface or clouds covering it. The scale ranges from 192 Kelvin (-114 Fahrenheit) in black/blue, to 320 Kelvin (116 Fahrenheit) in red. The Intertropical Convergence Zone, an equatorial region of persistent thunderstorms and high, cold clouds, is depicted in yellow.



Keeping track of the global carbon cycle on land and water became easier in 2003, too. Goddard scientists, using space-based measurements from the Terra and Aqua satellites, unveiled the first consistent and continuous global measurements of Earth's metabolism. With this data, scientists can produce composite maps of the world's "net primary production" every 8 days. Scientists expect this global measurement of biological productivity to yield new insights into how the Earth's carbon cycle works, a critical step toward solving the climate change puzzle and the impact of human-induced pollution on the environment.

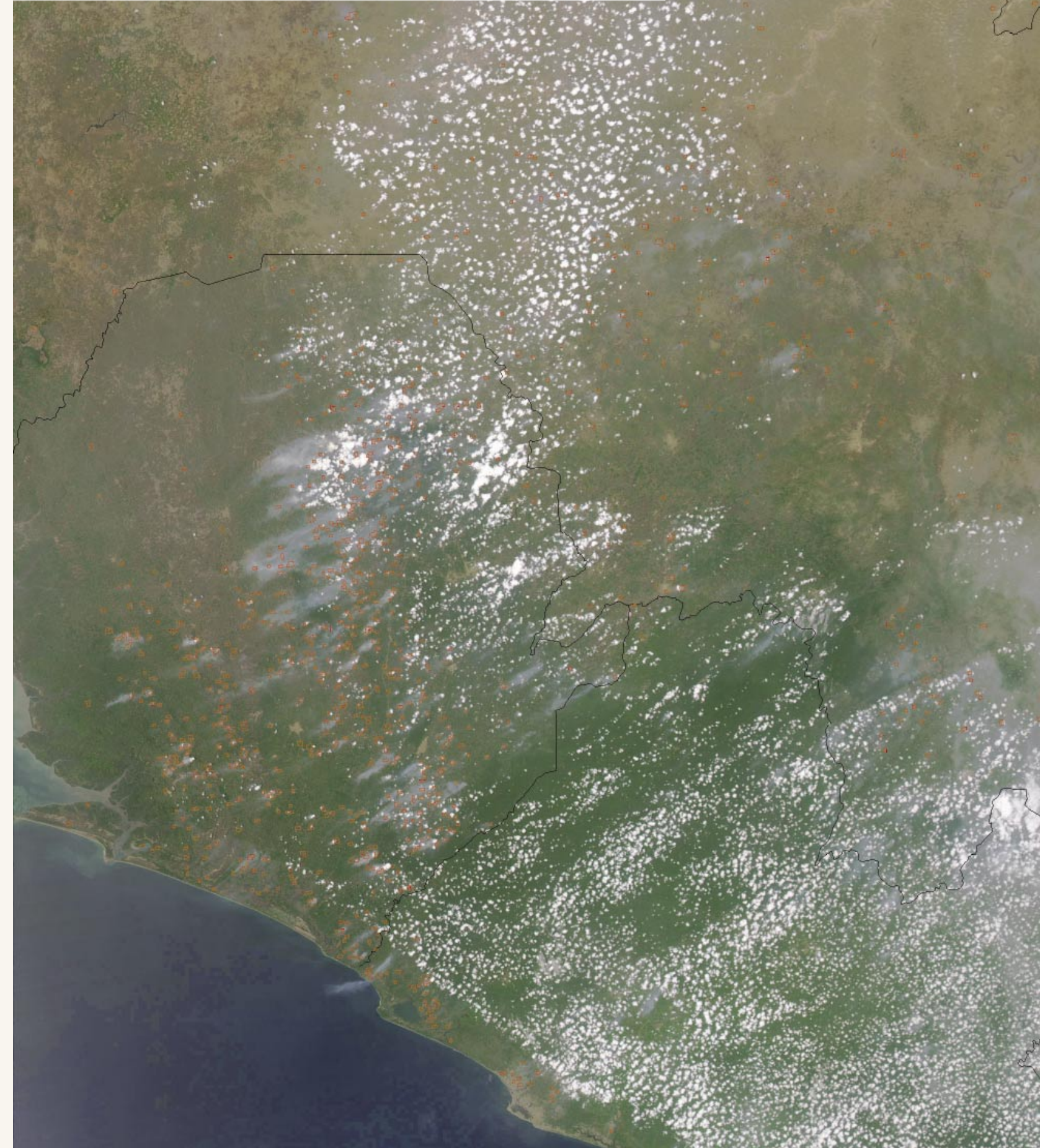
In the Forecast

Heat is also contributing to increased rainfall — particularly in large coastal cities like Houston. According to new research by Goddard and University of Arkansas researchers, urban heat islands created by pavement and buildings cause warm air to rise and interact with sea breezes to create heavier and more frequent rainfall in and downwind of these cities. The impact on weather, and possibly climate, could become increasingly more important as more people move to coastal cities, the researchers said.

The art of forecasting precipitation may become more precise because of new research by Florida State University researchers. They announced in 2003 that they had significantly improved weather forecasting just by adding ozone measurements taken by the Total Ozone Mapping Spectrometer Earth Probe into their models. In published reports, the scientists said that predictions of snowstorm intensity, snowfall amounts, and the storm track all improved for a storm that hit Washington, D.C. By knowing when and where the heaviest snow will fall during a storm, public works departments can better direct their snow removal equipment and estimate where problem areas could occur.

The capability to predict earthquakes also improved in 2003. Researchers from Goddard, the Jet Propulsion Laboratory, Ames Research Center, and several universities announced that they had made progress developing an advanced earthquake modeling system called QuakeSim. They expect to complete the system in late 2004.

The West Africa biomass-burning season that began in November 2002 was still underway by late March 2003. This true-color Moderate Resolution Imaging Spectroradiometer (MODIS) image from the Aqua satellite on March 24, 2003, shows scores of fires (in red) heavily concentrated in Sierra Leone, with other fires scattered across Guinea (top) and Liberia (bottom right). Biomass burning produces as much pollution as the use of fossil fuels.





◀ In January 2002, a dull star in an obscure constellation suddenly became 600,000 times more luminous than our Sun, temporarily making it the brightest star in our Milky Way galaxy. The mysterious star, called V838 Monocerotis, has long since faded back to obscurity. But observations by NASA's Hubble Space Telescope of a phenomenon called a "light echo" around the star have uncovered remarkable new features. These details promise to provide astronomers with a CAT-scan-like probe of the three-dimensional structure of shells of dust surrounding an aging star.

Pushing the Cosmological Envelope

The Goddard Space Flight Center was assured a bright future for space science in 2003, winning a membership in the NASA Astrobiology Institute, launching the Cosmic Hot Interstellar Plasma Spectrometer, which is examining the behavior of million-degree plasmas around our solar system and those in spiral galaxies in distant space, and choosing Time History of Events and Macroscale Interactions during Substorms (THEMIS) as the next medium-class Explorer program.

In 2003, the Center awarded the contract to manage the James Webb Space Telescope Science and Operations Control Center to the Association of Universities for Research in Astronomy. Goddard also announced that it had given the Far Ultraviolet Spectroscopic Explorer a new lease on life following the successful implementation of new software in three computers that work together to control the telescope's precision pointing.

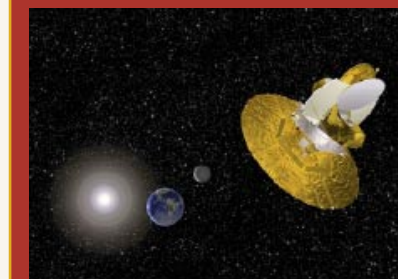
The following are snapshots of the year's important scientific discoveries.

Portrait of the Infant Universe

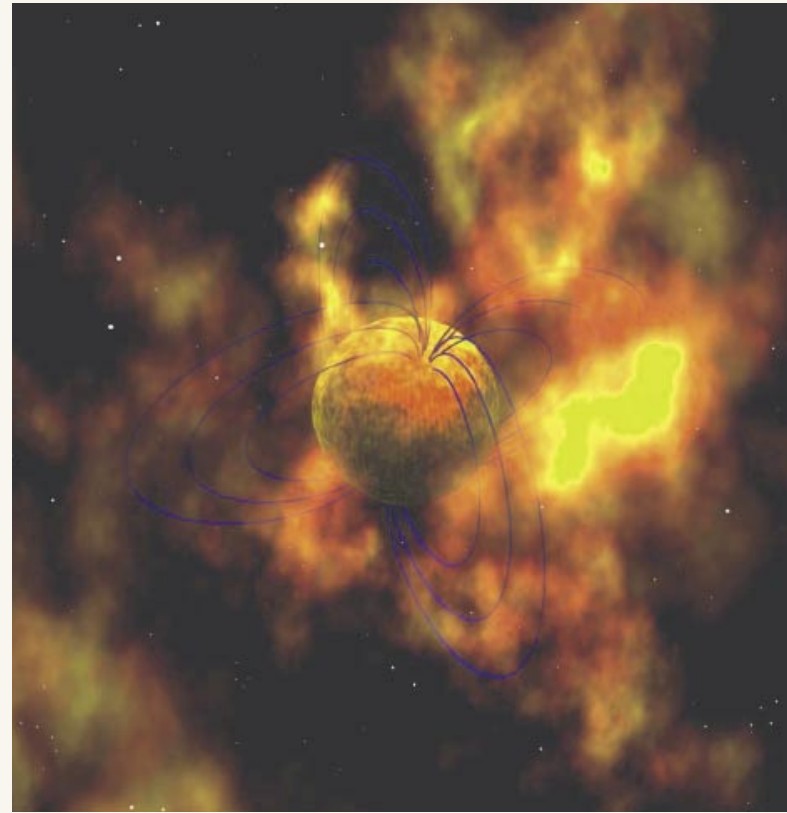
The scientific highlight of the year unquestionably came from the Wilkinson Microwave Anisotropy Probe (WMAP). The Goddard-built, Explorer-class spacecraft captured the afterglow of the Big Bang, revealing that the first stars ignited only 200 million years after the creation of the universe — much earlier than many scientists had expected — and precisely pegging the age of universe at 13.7 billion years old.

The WMAP team, made up of scientists from Goddard, Princeton University, and other universities, also discovered that the universe contains 4 percent atoms or ordinary matter, 23 percent dark matter, and 73 percent dark energy. The new measurements even shed light on the nature of the dark energy, which acts as antigravity. These discoveries represented a turning point for cosmology and a milestone in how scientists view the universe.

The spacecraft made these discoveries by precisely mapping the faint cosmic glow that bathes the sky in all directions. From this portrait, scientists studied the patterns caused by the fluctuations in temperature to unravel clues about the nature, composition, and destiny of the universe.



WMAP used the Moon to gain velocity for a slingshot to L2. After three phasing loops around the Earth, WMAP flew just behind the orbit of the Moon 3 weeks after launch. Using the Moon's gravity, WMAP steals an infinitesimal amount of the Moon's energy to maneuver into the L2 Lagrange point, one million miles (1.5 million km) beyond the Earth.



In 2003, scientists discovered the most magnetic object in the universe, an intensely magnetic neutron star. In this artist's concept of the object, the blue lines emanating from the magnetar's pole represent its powerful magnetic field, which is strong enough to erase a credit card's magnetic strip from 100,000 miles (160,000 kilometers) away.

as it appeared about 5 billion years ago when the familiar web-like structure of galaxy chains and voids first emerged. Chandra saw a rich density of active galaxies, seven times denser than what has been detected in previous surveys.

Space Exotica

Although NASA spacecraft have ushered in a new era of discovery, much of the universe remains a mystery.

Scientists discovered one such mystery in 2003. Using NASA's Rossi X-ray Timing Explorer satellite, scientists identified the most magnetic object known in the universe. By following the fate of tiny protons whipping around at near light speed close to a neutron star, scientists calculated this star's magnetic field to be up to 10 times more powerful than previously thought — with a force strong enough to slow a steel locomotive from as far away as the Moon. This object, named SGR 1806-20, is one of only 10 unusual neutron stars classified as magnetars, thousands of times more magnetic than ordinary neutron stars and billions of times more magnetic than the most powerful magnets built on Earth.

Scientists also announced in 2003 that gravitational radiation — ripples in the fabric of space predicted by Albert Einstein — might prevent pulsars from spinning too fast and blowing apart. Pulsars are the fastest spinning stars in the universe, and are the core remains of exploded stars. Containing the mass of our Sun compressed into a sphere about 10 miles across, a pulsar gains speed

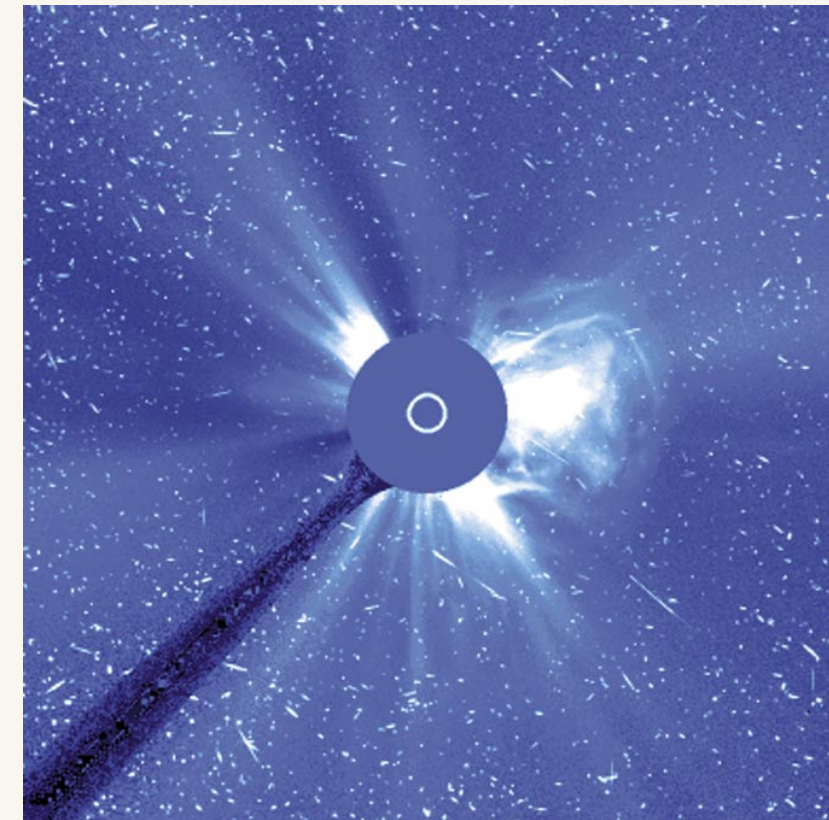
In so many ways, WMAP has been a mission of firsts. Although Goddard has a long history of managing Explorer-class missions, Center scientists had never competed for an Explorer mission. Before WMAP, Goddard had never worked closely with a university to build a major science mission, either. The teaming arrangement with Princeton University is now considered a model. And before WMAP, no satellite had ever flown in the L2 orbit, a quasi-stable position in the opposite direction of the Sun. Although many satellites have passed through the L2 neighborhood, none have used it as a permanent observing station.

The Universe as an Adolescent

A few months after scientists unveiled the detailed portrait of the early universe, scientists released an image taken by the Chandra X-Ray Observatory that showed the adolescent universe. The image showed the universe

by pulling in gas from a neighboring star, reaching a spin rate of nearly one revolution per millisecond or almost 20 percent the speed of light. Using the Rossi X-Ray Timing Explorer, scientists found a limit to how fast a pulsar spins and attributed the cause to gravitational radiation. These exotic waves, which are like ocean waves, are ripples in four-dimensional space-time. Caused by massive objects in motion, scientists have not yet directly detected them.

Using the High-Energy Transient Explorer, scientists also detected one of the brightest and closest gamma-ray bursts, signaling the birth of a black hole in the constellation Leo. For more than 30 seconds, the burst outshined the entire universe in gamma rays and its afterglow was still more than a trillion times brighter than the Sun two hours later.



A three-spacecraft collaboration recorded for the first time the entire process of a high-speed eruption of electrified gas from the Sun. This picture shows the so-called coronal mass ejection (CME) as viewed by the Solar and Heliospheric Observatory. The image is in false color; the white areas are concentrations of electrified gas in the Sun's atmosphere. The CME is the large, wispy white cloud seen to the right of the blue disk. Scientists study CMEs because they can disrupt communications and power grids on Earth if the eruption hits the planet directly. Other spacecraft involved in the observation included the Reuven Ramaty High Energy Solar Spectroscopic Imager and the Transition Region and Coronal Explorer.

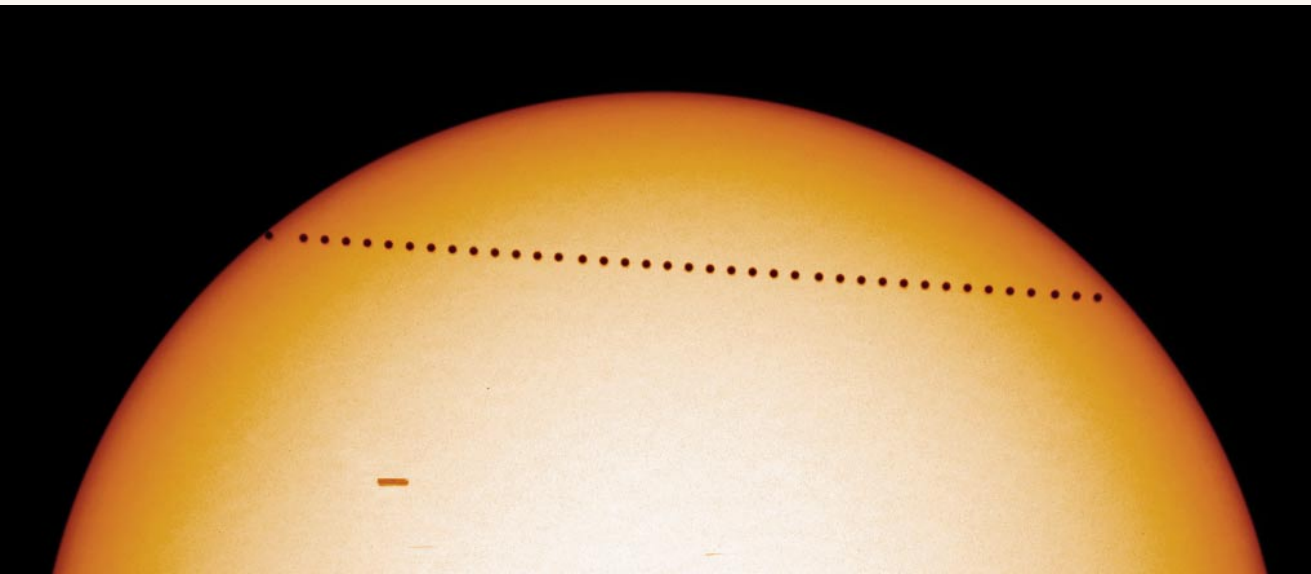
©1997 by Fred Espenak



The NASA Astrobiology Institute announced in 2003 that the Goddard Space Flight Center would lead the effort to discover if comets supplied the raw material for the origin of life on Earth. The research effort will take 5 years.

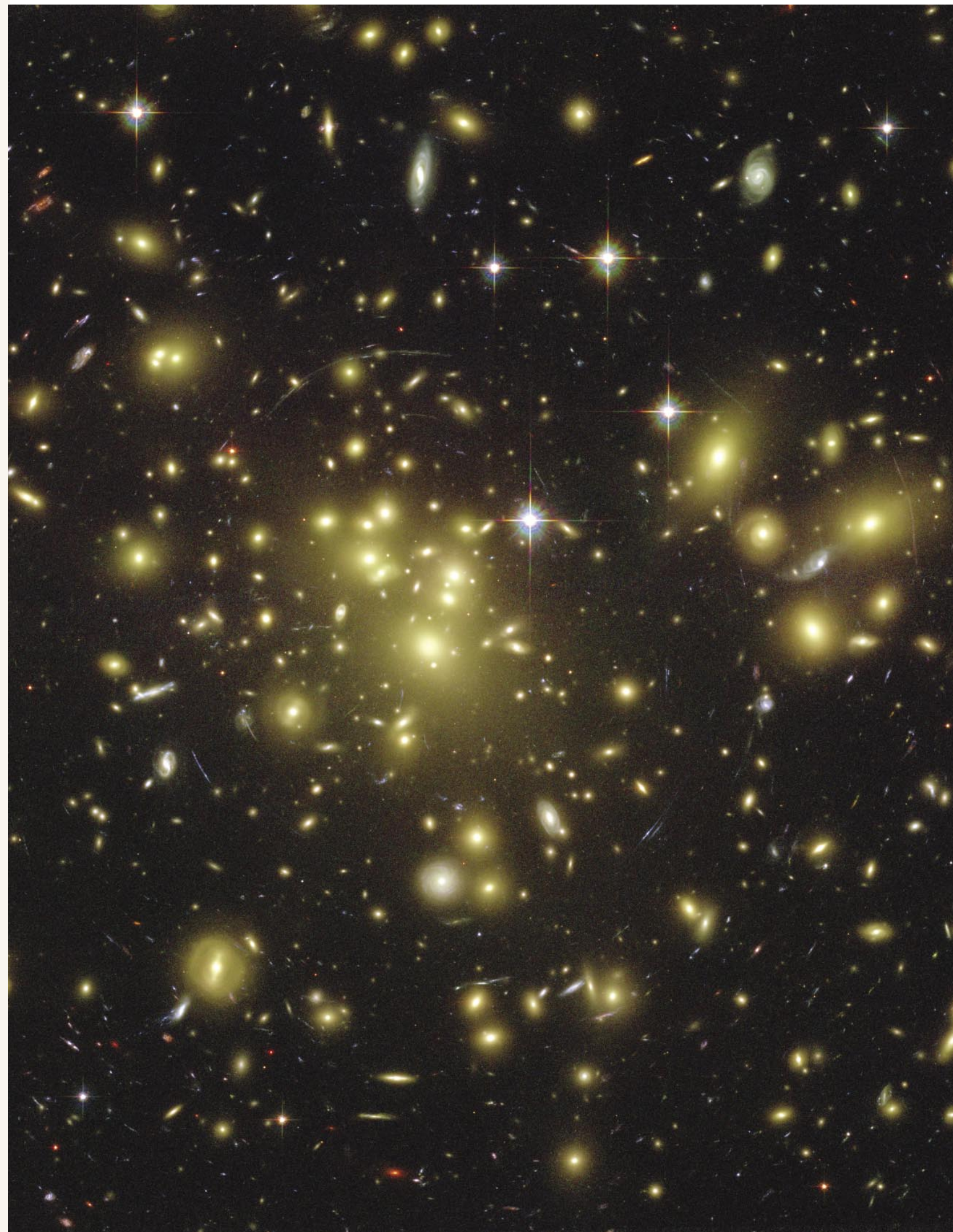
New Planet Discovery

Heralding another first, the Hubble Space Telescope measured the mass of the farthest and oldest-known planet. The ancient planet, which formed long before our Sun and planet ever existed, lies near the core of the ancient globular star cluster M4, located 5,600 light-years away in the constellation Scorpius. The planet is 2.5 times the mass of Jupiter and its very existence provides tantalizing evidence that the first planets formed rapidly, within a billion years of the Big Bang, leading astronomers to conclude that planets may be abundant in the universe.



The Solar and Heliospheric Observatory captured this image of Mercury passing in front of the Sun in an unusual event called a transit. Only occurring a dozen times per century, the transit happened on May 7, 2003 and lasted slightly more than 5 hours.

The Advanced Camera for Surveys aboard the Hubble Space Telescope used a natural "zoom lens" in space to boost its view of the distant universe. To capture this image, Hubble peered straight through the center of one of the most massive known-galaxy clusters, Abell 1689. The gravity of the cluster's trillion stars, plus dark matter, acted as a gravitational lens, bending and magnifying the light of galaxies far behind it. Consequently, the image revealed remote galaxies previously beyond even Hubble's reach.



◀ Goddard technologists have developed this relatively small refrigeration system that in the future could be used to cool ultra-sensitive detectors required for X-ray, infrared, and sub-millimeter missions. The so-called continuous adiabatic demagnetization refrigerator pictured here operates continuously at temperatures of 50 milliKelvin and below.

Advancing NASA's Technology Portfolio

Carrying out research in the Earth and space sciences requires a steady infusion of new technology. In 2003, technologists at the Goddard Space Flight Center promoted a diversified portfolio of scientifically relevant technologies that struck a balance between short-term, mission-focused technologies and long-term strategic needs — technologies that may find homes in projects carried out by other NASA organizations.

Goddard remains uniquely positioned to carry out this assignment. The Center executes the majority of the Agency's science missions and employs more than half of NASA's scientists and technologists. These specialists work as partners to clearly define scientific requirements now and in the future.

Carbon Nanotubes

A prime example of Goddard's willingness to partner occurred in 2003 when technologists, working with researchers at the Ames Research Center, studied the feasibility and possible use of nanotube technology in the Hubble Space Telescope Imaging Spectrograph (STIS) Thermal Interface Kit (STIK), a new piece of equipment that astronauts will install on the Hubble Space Telescope during the fourth servicing mission. STIK will act as an interface between Hubble's STIS and a new capillary pumped loop designed to divert heat away from the spectrograph, which is highly sensitive to excessive heat. Although researchers discovered nanotube technology a decade ago, this is the first time NASA has seriously considered use of the technology in a space mission.

Microshutter Array

The Goddard Space Flight Center is pursuing another revolutionary technology — NASA's first-ever Micro-Electro-Mechanical Systems (MEMS) sensor that ultimately will fly on the James Webb Space Telescope's Near-Infrared Spectrometer. Featuring millions of microscopic shutters aligned on a silicon grid — each no larger than a dust mite — the large-format device will perform like the aperture plate on ground-based spectrometers. Ground controllers will send commands directing specific shutters in the array to open or close, allowing the science instrument to take near-simultaneous spectral measurements of specific objects in the telescope's field of view. This year, the microshutter met a critical milestone, successfully demonstrating a fully functional 128 x 64 pixel module. Ultimately, the flight-ready model will contain 175 x 384 pixel modules.



Constellation-X, a flagship mission of NASA's "Beyond Einstein" program, will measure the velocities and conditions of matter falling into black holes and will map hot gas and dark matter to help determine how the universe evolved large-scale structures seen in the cosmos today. The proposed mission includes four spacecraft, each containing a 1.5-meter diameter telescope for measuring the spectra of X-rays. To develop the mission, Goddard is currently working on technologies needed to create a new flight mirror assembly, which will allow up to 100 times more observing power within a particular X-ray energy band than what current terrestrial or spaceborne observatories can provide. These technologies include the development of a repeatable and reliable process for forming, assembling, applying gold coating, and precisely aligning each of the nearly 16,000 mirror segments (each with a thickness of about 400 microns) to sub-millimeter accuracy.

Continuous Adiabatic Demagnetization Refrigerator

Miniaturization is vital to the future of Earth and space science missions, as demonstrated by the microshutter array and carbon nanotubes. Advanced cooling technologies for ultra-sensitive detectors required for X-ray, infrared, and sub-millimeter missions, also are critical to missions of the future. Since the lifetime requirements for these missions extend well beyond what traditional cryogenic systems can handle, Goddard has developed a continuous adiabatic demagnetization refrigerator which operates continuously at temperatures of 50 milliKelvin and below. Currently, technologists are working to fully optimize the refrigerator's performance and demonstrate temperature control at the level needed to operate detectors.

Lightweight Rainfall Radiometer

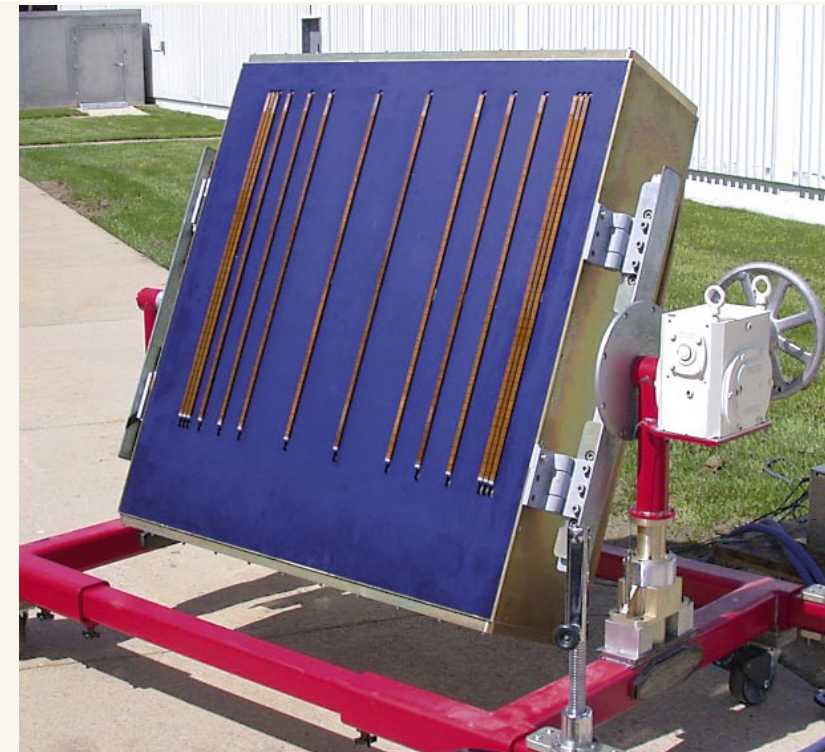
In the category of developing technology that NASA can use in future missions, engineers also reported progress on the next-generation lightweight radiometer, which scientists hope to ultimately employ to measure global precipitation from space. This year, they flew an experimental Synthetically Thinned Aperture Radiometer (STAR) on a DC-8 aircraft. Developed jointly by Goddard and the University of Michigan, the instrument performed as planned, discriminating between hot and cold temperature differences.

CANDOS Experiment

On January 31, 2003, Goddard researchers flew another experiment — the Communications and Navigation Demonstration on Shuttle (CANDOS) — on the Space Shuttle to demonstrate the integrated communications and navigational functions of the Lower Power Transceiver (LPT). Developed by Goddard and ITT Industries for the Office of Space Flight, the modular multi-band, multi-channel transceiver demonstrated ground- and space-network communica-

A 39.57 million cubic foot NASA scientific balloon carrying the Trans-Iron Galactic Element Recorder (TIGER) awaits launch near McMurdo Station, Antarctica, for its 32 day journey around the South Pole. NASA is developing balloon systems capable of flying science instruments such as TIGER for durations of up to 100 days.

Photo courtesy of Jason Link, Washington University



This experimental Synthetically Thinned Aperture Radiometer (STAR), developed jointly by Goddard and the University of Michigan, flew on a NASA DC-8 aircraft in 2003. An instrument like it could one day carry out future global rainfall measuring missions.

tions, Global Positioning Satellite (GPS) navigation, mobile IP and IP-in-space, space-based range safety, and on-orbit reconfiguration.

Formation Flying

Another promising technology is formation flying — a key technological innovation required by the Micro-Arcsecond X-Ray Imaging Mission (MAXIM), which would directly image a black hole using an X-ray interferometer made up of 25 spacecraft. To achieve the mission's goals, however, NASA must perfect the technologies needed for autonomous formation flying. Goddard technologists made significant progress this year in key subsystem technologies, including advanced relative navigation, formation control, intersatellite communication, formation design, and modeling and simulation. A key element in this work is Goddard's Formation Flying Test Bed (FFTB), which has become the predominant facility for evaluating formation-flying technology.

Sensor Webs

Goddard also is exploring the use of sensor webs — a diverse collection of instruments performing coordinated, or even collaborative, measurements of fires, volcanic eruptions and other natural phenomena. This year, NASA investigators, working with the NASA Wildfire Response team, demonstrated the concept by establishing a network including instruments on Aqua, Terra, and EO-1. The team also employed an innovative software application, the Science Goal Monitor (SGM), to analyze instrument data and flag those of interest. When a fire was identified, SGM analyzed Aqua and Terra fire data to isolate the latest center of activity and then it automatically coordinated with mission planning systems to request and analyze a high-priority, high-resolution image from EO-1. Forest officials received the high-resolution image within 48 hours. Currently, the typical lead-time for preplanned observations is up to 14 days.

NASA's ability to fuse satellite data is proving valuable to land management experts. In this photo, U.S. Forest Service personnel are assessing post-forest fire damage, using Burned Areas Reflectance Classification maps created from fused NASA satellite data. Maps such as these help Burned Area Emergency Rehabilitation teams direct treatments for high-risk areas while making efficient use of available resources.



Goddard researchers flew this experiment — the Communications and Navigation Demonstration on Shuttle (CANDOS) — to test the integrated communications and navigational functions of a new modular multiband, multi-channel transceiver developed by Goddard and ITT Industries.



◀ In collaboration with the Smithsonian Institution Traveling Exhibition Service, this year the Goddard Visitor Center debuted its new exhibit, "Hubble Space Telescope: New Views of the Universe." The exhibit includes Hubble images of planets, galaxies, black holes, and many interactive displays, including a computer simulation that allows visitors to hit Jupiter with a comet.

Reaching Out to Others

As NASA works toward returning to flight, it faces another challenge that could affect the Agency's ability to carry out its vision and mission in the future. The NASA workforce is getting older and fewer young people who are U.S. citizens are choosing technical careers. At the Goddard Space Flight Center, for example, more than 40 percent of the scientists are now 55 or older, while fewer than 15 percent of the engineers are younger than 35. In other words, Goddard is facing a critical loss of technical expertise and a very real challenge of replacing it.

To correct the imbalance and inspire future generations to pursue careers in science, technology, engineering, and mathematics, NASA has charged the newly-created Education Enterprise with inspiring the next generation of explorers. Within a year, the new enterprise had instituted several new programs designed to fill the pipeline with professionals NASA needs to carry out its mission.

Explorer Schools

One of the most ambitious programs launched in 2003 was the NASA Explorer Schools Program, a 3-year initiative that exposes middle-school-age students to the application of science, technology, engineering, and mathematics to real-world problems, while providing educators with customized training in technology-based teaching techniques, critical thinking, and curriculum development.

As part of the program, NASA provides one-on-one in-service support to each of the Explorer Schools and funds a variety of professional development programs during the summer. Unlike any other NASA Center, Goddard also has committed to providing a minimum of 60 days of in-service support, as well as scientific support to each of its five Explorer schools in Vermont, Massachusetts, Connecticut, New York, and Washington, D.C. By investing more time with teachers and students, Goddard educational professionals hope to significantly improve technical literacy at these schools.



Astronaut Don Pettit, who had recently returned from a 4-month stay on the International Space Station, visited students, teachers, and parents at Anne Beers Elementary School as part of Goddard's "Blast Back to School" program. The special event, which included the distribution of NASA-inspired school supplies, was held to recognize the school's selection as 1 of the 50 NASA Explorer Schools, a 3-year program aimed at sparking innovative science and math instruction in middle schools.





Photo courtesy of Daniel Splaine, JASON Foundation

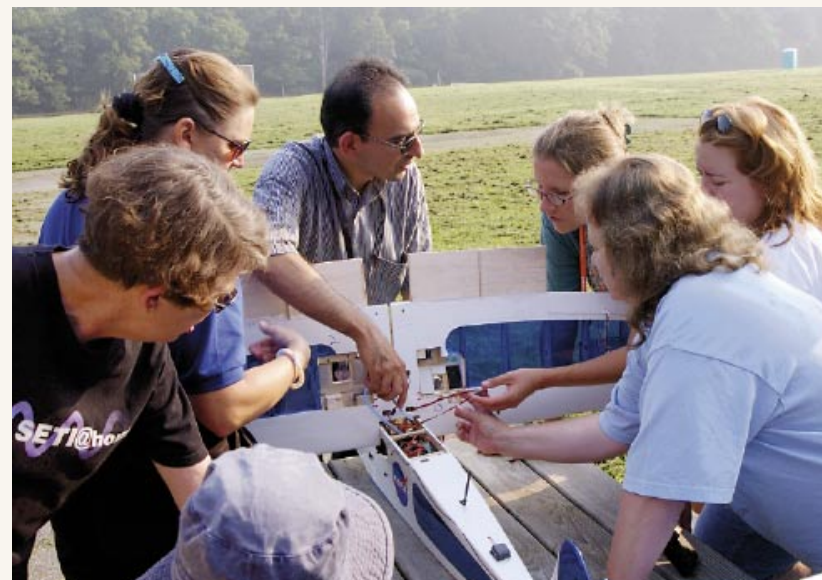
Goddard-region JASON student astronaut Jessica Mahamood, prepares NASA's UAV for mission flight.

NASA/JASON Project Channel Island Mission

Meanwhile, across the country in the Channel Islands, Goddard put its remote sensing technology to work as part of the JASON XIV: From Shore to Sea expedition in January 2003. Begun in 1989, the JASON Project unites scientists with 34,000 teachers and 1.7 million 4th to 9th-grade students in hands-on scientific field expeditions. This year, the students used data from four NASA satellites (Terra, Aqua, Landsat 7, and SeaStar) and an Uninhabited Aerial Vehicle (UAV) equipped with cameras and thermal sensors to collect data and monitor sea surface temperatures, vegetation, and productivity. Students and teachers also used Moderate Resolution Imaging Spectroradiometer (MODIS) data to monitor chlorophyll concentrations and derive fluorescence in the Channel Islands area off the coast of California. JASON participants across the country used Goddard's newly developed Image Composite Editor tool to manipulate satellite data, which is later compared with plane and ground-based observation measurements. With this information, the students were able to determine the abundance, condition, and variability of life in the area during El Niño conditions.

Remote Sensing Earth Science Teacher Program (RSESTeP)

Seventeen JASON Project teachers from across the U.S. then visited Goddard in the summer for a week-long training workshop to learn how to use remote sensing techniques to plan and implement local Earth science missions with their students. As part of the new Remote Sensing Earth Science Teacher Program, Goddard and Wallops supplied the teachers and their students with local satellite data, a GPS receiver, temperature sensors, and a handheld weather station, in addition to a remote-controlled UAV plane equipped with a video camera and a thermal infrared imager. In partnership with local scientists and pilots, teachers were able to implement local Earth science missions with students. In exchange, the teachers are helping Goddard education specialists develop an RSESTeP mission module.



GSFC engineer Patrick Coronado instructs JASON Project teachers in how to attach UAV wing aileron wires.

Outreach in the Big Apple

Goddard also made headway among students of all ages in the New York City area. In 2003, Goddard launched the New York City Research Initiative, which pairs high school and undergraduate students and teachers with graduate students and principal investigators who are conducting NASA-funded research at universities within a 50-mile radius of the city. At the request of a city councilman, Goddard is also assisting with the formulation and implementation of an after-school enrichment program to expose high school students to science, technology, engineering, and mathematics. Many of these students were personally affected by the terrorist attacks on the World Trade Center. And in 2003, Goddard provided educational materials to the New York City New Century High School Project, a charter school network supported in part by a \$51 million grant from the Bill Gates Foundation. The school project also is discussing the possibility of establishing one of its high schools as a NASA science, technology, engineering, and mathematics high school.

Promoting Technical Careers

To expose students to careers important to NASA, Goddard prepared a mock-up Web site for the Maryland Business Roundtable for Education, a nonprofit organization that promotes high-quality, standards-based education in the state. Still under development, the Web site will introduce 9th-grade students to Goddard information technologists, scientists, and engineers, and allow them to explore what these people do to earn a living. Encouraging students to make more informed course selection decisions during their high school years is the goal of this program.



A 75-foot Mercury Redstone rocket, which launched the first Americans into space, and a full-size replica of the Wright Flyer, seen in the foreground, served as centerpieces for "GE Presents Centennial of Flight at Rockefeller Center," held July 28–Aug 17, 2003 in New York City. The two models, representing the first 100 years of powered flight, were placed on the same site as the world famous Rockefeller Center Christmas tree.

Students with Disabilities

This year also proved productive in efforts to reach out to those with disabilities. Goddard Director A.V. Diaz attended the annual National Federation of the Blind convention and gave the keynote address encouraging the blind to consider entering scientific and mathematical fields. The NASA Office of Space Science also helped to fund the production of a new Braille book featuring images by the Hubble Space Telescope. The 64-page book, titled *Touch the Universe: A NASA Braille Book of Astronomy*, presents color images of planets, nebulae, stars, and galaxies, each embossed with lines, bumps, and other textures. Finally, during the summer of 2003, Goddard hosted a national teacher workshop on how to use NASA educational materials with special populations.

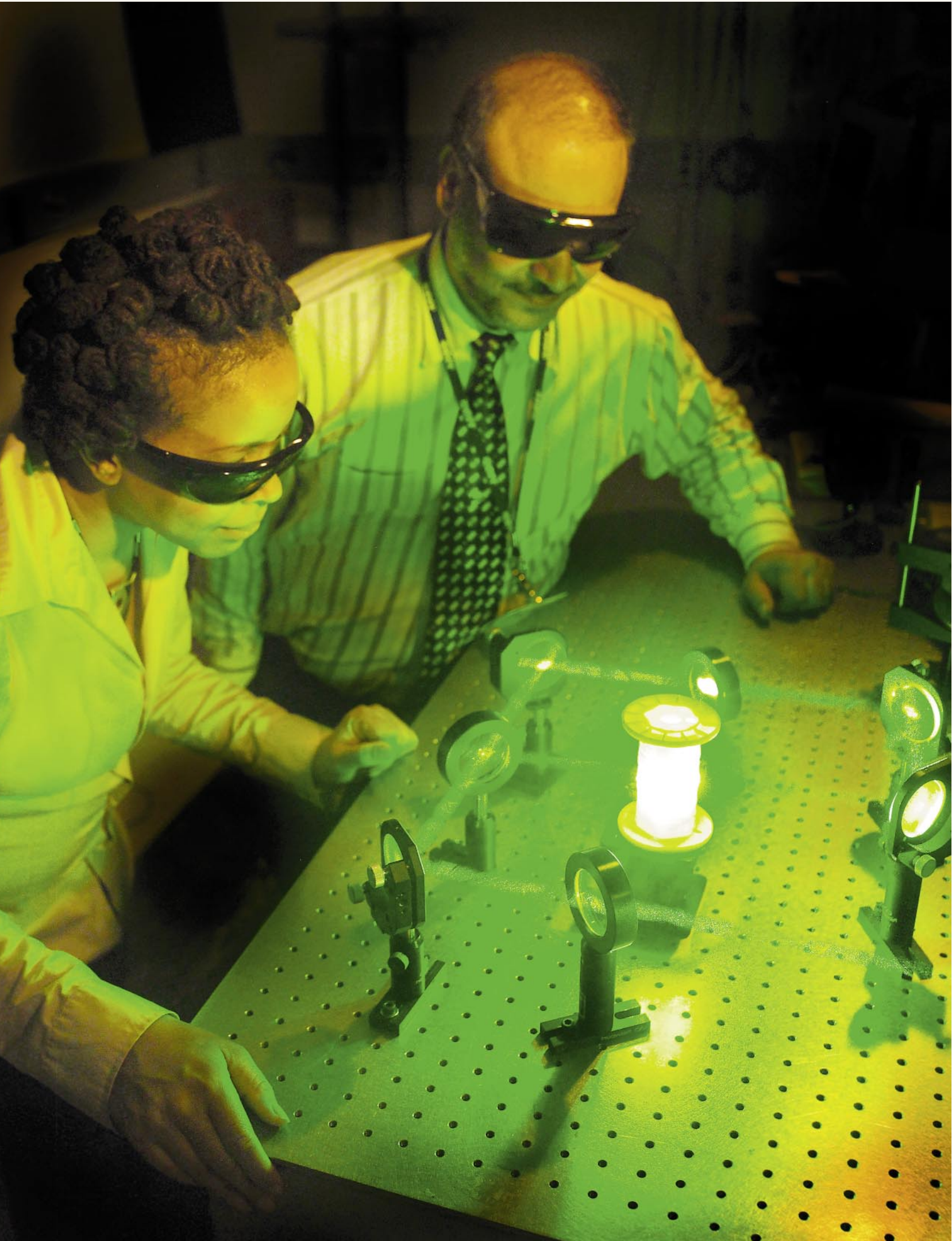


Goddard professionals learned firsthand what it is like to be physically impaired in a one-of-a-kind workshop held at the Goddard in 2003.



*Goddard Director A.V. Diaz and a blind student read through a copy of NASA's print/Braille tactile-image book, *Touch the Universe: A NASA Braille Book of Astronomy*, at a book release event held at the National Federation of the Blind's national headquarters in Baltimore. More than 30 blind school children — including Baltimore City public school children, Loyola High School students, and students from the Maryland School for the Blind — were on hand to celebrate the release of the book.*

◀ A demonstration is shown of a novel light-weight, compact, rugged, and broad wavelength fiber laser system for use in several space applications.



Goddard Space Flight Center Financials

Progress with NASA's Integrated Financial Management Program

The Integrated Financial Management Program (IFMP) is an Agency-wide effort to improve NASA's management of its financial, physical, and human resources through the implementation and use of multiple enterprise applications. Begun in 2001 and scheduled for completion in 2006, the program has reached a significant milestone with the three-phased implementation of the Core Financial module in FY 2003.

This Core Financial module provides the Agency with standards for a broad range of accounting and budgetary processes and financial reporting. It is the backbone of the IFM system, supporting improved information exchange with end-users and stakeholders. It also serves as the technical underpinning for NASA's eCommerce and eGovernment initiatives and, as such, will play a key role in improving financial management at Goddard Space Flight Center and throughout the Agency.

Specifically, the Core Financial module will support a number of functions:

- Enabling regulatory compliance more efficiently;
- Establishing standard management and reporting business processes across NASA;
- Updating technology to increase efficiency, functionality, and flexibility;
- Implementing a single, integrated information and financial management system;
- Providing automated audit trails, data processing, reporting, and security measures;
- Implementing full cost accounting agency-wide on a timely basis; and
- Providing current, reliable reports to internal customers (e.g., management) and external customers (e.g., Congress, OPM, OMB, and the Department of the Treasury).

In October 2003, Goddard Space Flight Center also implemented Release 0.5a of the Budget Formulation module. The Center is expected to roll out Release 0.5b and Release 1.0 in February and June 2004, respectively. When fully implemented, the Budget Formulation module will provide a "decision support" tool to formulate project, program, institutional, enterprise, and Agency-level budget requirements. This tool also will promote full-cost management and

Civil Service Staffing

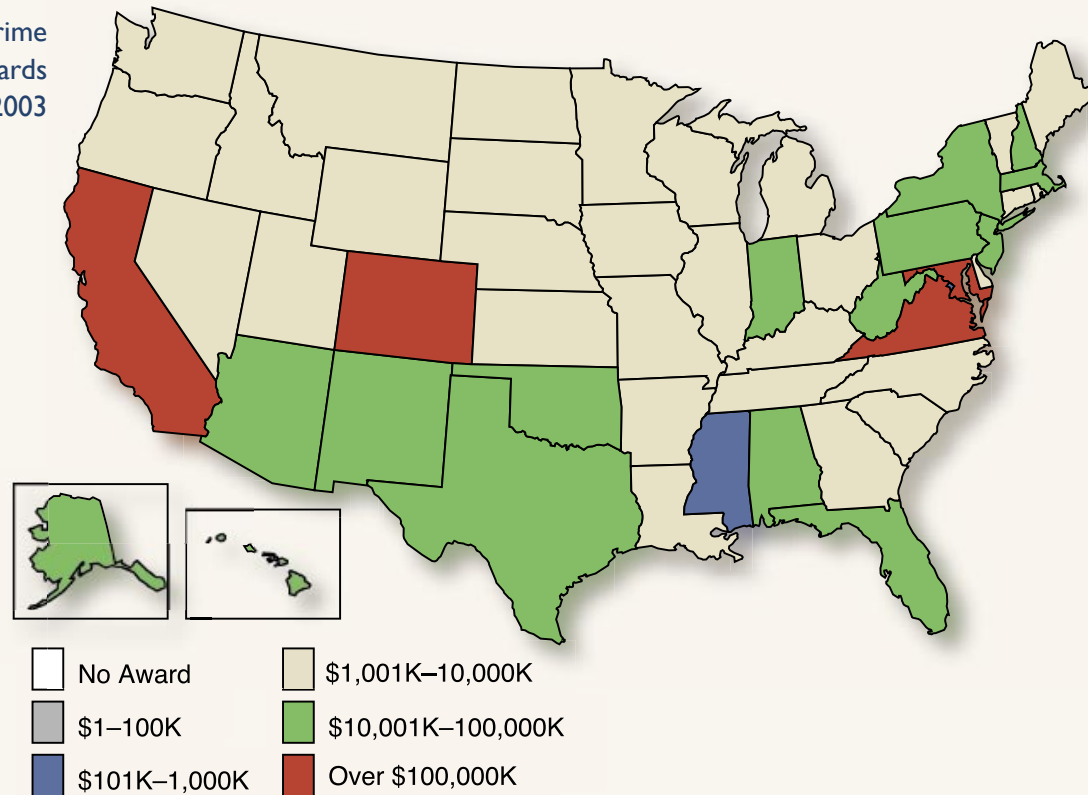
Scientist & Engineer	58.7%
Professional/Admin.	26.2%
Clerical	7.1%
Technician	6.6%
Wage Grade	1.4%

real-time decision-making. When integrated with the Core Financial module, the Budget Formulation module will provide budget execution controls within the Core Financial applications.

After implementing five of nine scheduled enterprise modules, IFMP is well on its way to reengineering NASA's business infrastructure using industry best-practices and enabling technology to provide necessary management information to support NASA's strategic plan.

Total Goddard Funding FY2003 (\$M)	
Space Science	1,353.5
Earth Science	993.2
Biological and Physical Research	2.6
Aeronautics	6.9
Education Programs	90.4
Space Flight	57.2
Crosscutting Technologies	85.2
Reimbursables	286.2
TOTAL	2,875.2

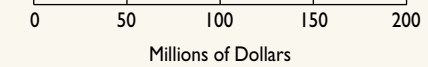
Total Prime Contract Awards for FY 2003



GSFC Top 10 Nonprofit Institutions for FY 2003

Institution	Number of Contracts	Millions of Dollars Obligated
Johns Hopkins University	137	\$185.4
Assoc. of Universities for Res. in Astronomy	29	\$74.9
University of Colorado – Boulder	180	\$36.9
University of California – Berkeley	107	\$31.6
Stanford University	41	\$27.8
California Institute Technology	82	\$20.4
Institute Scientific Research, Inc.	4	\$18.3
Universities Space Research	51	\$17.7
New Mexico State University – Las Cruces	19	\$17.5
University of Maryland – College Park	151	\$17

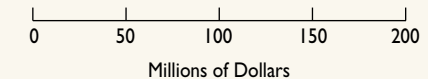
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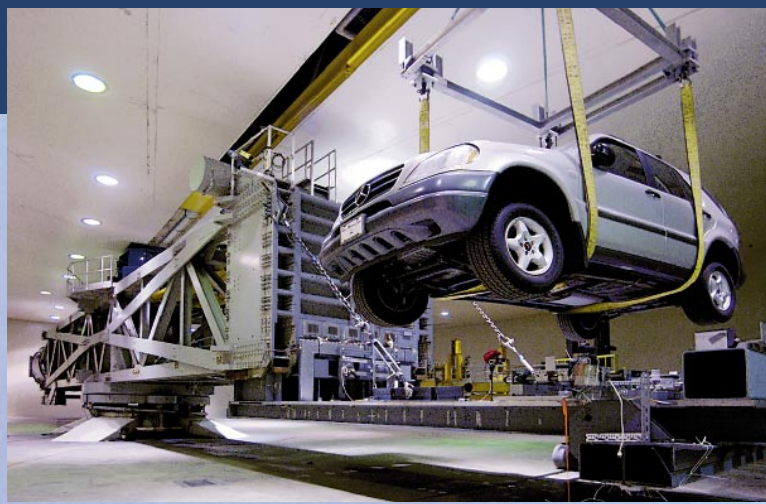
GSFC Leading Contractors for FY 2003

Company	Number of Contracts	Millions of Dollars Obligated
Boeing Satellite Systems, Inc.	2	\$164.4
Lockheed Martin Corp.	29	\$132.8
Raytheon Information Systems Co.	2	\$110.9
Ball Aerospace & Tech. Corporation	14	\$78.8
TRW, Inc.	4	\$71.5
QSS Group, Inc.	4	\$63.0
Science Systems Applications	12	\$62.9
Northrop Grumman Systems Corporation	4	\$60.0
Swales & Associates, Inc.	4	\$49.7
Mantech Systems Engineering Corp.	1	\$26.3
Cube Corporation	1	\$26.3
ITT Corporation	10	\$25.7
P R C, Inc.	1	\$23.8
Science Application International Corp.	13	\$23.7
Cortez III Service Corporation	1	\$23.0
Spectrum Astro, Inc.	2	\$20.0
Computer Sciences Corporation	28	\$18.9
Averstar, Inc.	2	\$17.6
SGT, Inc.	15	\$17.5
Parsons Infrastructure & Tech.	2	\$12.7
Honeywell Technology Sols., Inc.	20	\$10.9
ACS Government Solutions Group	4	\$10.2
Global Science & Tech., Inc.	8	\$9.8
L B & B Associates, Inc.	2	\$9.7
Indus Corporation	1	\$9.4

Source: PR353PRE (Format H) Report



Federal highway safety officials came to NASA, testing a variety of ordinary cars and SUVs on the space agency's giant centrifuge.



Goddard Space Flight Center A Year in Review

Goddard Director A.V. Diaz and Langley Research Center Director Roy Bridges sign a Memorandum of Understanding to strengthen and formalize a strategic relationship between the two Centers in the areas of science mission management and system design and implementation. The two Directors signed the MOU during the One NASA Workshop held at GSFC in November 2003.



NASA Administrator Sean O'Keefe visited Goddard for an important NASA update to all Agency employees on the topic of Return to Flight.



NASA's Associate Administrator for Education Dr. Adena Loston reviews a bulletin board created by a NASA Explorer School teacher during a week-long summer workshop held at Goddard.



TOP: The first Quality of Work Life Expo took place in April 2003, which was a day-long event of activities and booths representing the various clubs, organizations, and benefit offerings at Goddard.

ABOVE: Officials from the National Federation of the Blind, including Dr. Betsy Zaborowski, NFB director of special programs, Dr. Marc Mauer, NFB president and Mr. Jim Gashel, Director of Governmental Affairs, tour GSFC facilities.

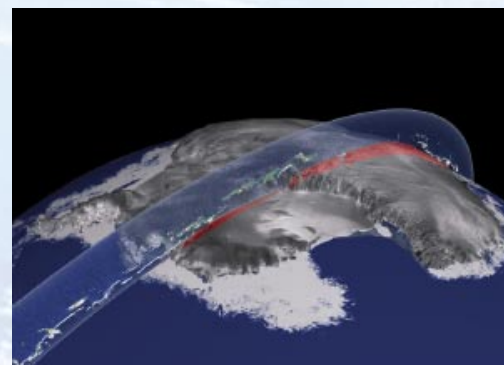


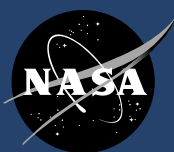
Barry Green, Goddard Energy Manager (far left), receives a plaque from former EPA Administrator Christine Todd Whitman at the dedication of the Landfill Gas Project at Goddard. Holding a Certificate of Appreciation presented to NASA by the EPA are NASA Administrator Sean O'Keefe (far right) and Goddard Director A.V. Diaz.



Goddard Aerospace Education Services Program instructor Ron Ernst gives a lecture to middle school students at the Brookhaven National Labs Museum in Upton, Long Island, NY.

An illustration of ice sheet elevation and cloud data from ICESat's Geoscience Laser Altimeter System (GLAS) on its first day of operation, February 20, 2003.





National Aeronautics and
Space Administration

Goddard Space Flight Center