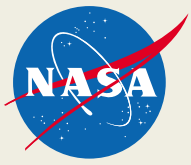
2001

Goddard Space Flight Center

# Goddard Space Flight Center Annual Report



## Vision

*We revolutionize knowledge of the Earth and the universe through scientific discovery from space to enhance life on Earth.*

## Mission

Goddard Space Flight Center enables discovery through leadership in Earth and space science.

We serve the scientific community, inspire the Nation, foster education, and stimulate economic growth.

We partner with others to achieve NASA's goals.

We create technologies that support and advance these endeavors to take full advantage of doing research in space.

We accomplish this through innovation in all that we do.

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# Message from the Director

September 11, 2001, changed us forever. How profound the impact of that day. It has affected us and has filtered our view of our achievements. Before that day, it would have been easy for me to name the many accomplishments, discoveries, milestones and completion of major projects as the capstone of so many dreams. However, because of that day and since that day, our thinking is directed constantly at our people in a more immediate way. We've become closer than ever before.

This year's Annual Report is not only our accounting to you, but also this year it is a celebration of our people. Our staff members, a highly diverse group in demographics and skills, represent our strength. We recognized that before the tragedy of September. But now we actively behave everyday according to that philosophy…from choosing team members for tasks to inclusion at all levels of management. Our people provide our achievements and accomplishments. They come from all backgrounds, interests, ages, skills. And together, our people stand for the hope of tomorrow. Our employees not only create our achievements, but also give this Nation their commitment to progress in our understanding of the universe and the Earth.

Please take a few moments to read our Report. Read the words of our staff members as they describe a moment of discovery. Observe how, thanks to innovation and creativity, a complex question yields an exquisite answer leading to other provocative questions. Become familiar with some of our people using this Report.

They represent many, many others who bring forward equal amounts of dedication and passion to space exploration, from hands-on engineering to supportive administrative work. I am very proud to share this Report with you because I am very proud of Goddard people at Greenbelt, Maryland; Wallops Flight Facility in Virginia; Goddard Institute of Space Studies in New York; the Independent Verification and Validation Facility in West Virginia and the staff at White Sands, New Mexico.

This document reports to you not only our desire to carry on the grand mission of the Center, but also our desire to cherish for a moment longer what is truly important to us, our people. I hope you will join me in that celebration as you read through our year's story through the impressions of individuals involved in missions, support help, transitions, discoveries or engineering and technology.

Sincerely,

A.V. Diaz, Director

“Show me a hero and I will write you a tragedy.”

F. Scott Fitzgerald

This year’s Annual Report is dedicated to
the thousands of Americans who lost their lives in the tragic events
of September 11, 2001.



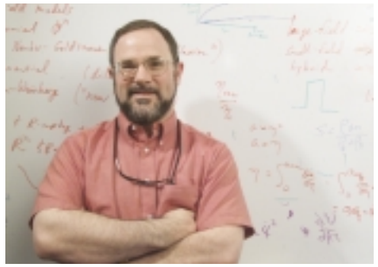
# Voices of Goddard

*Discovery is the business of the Goddard Space Flight Center, and fiscal 2001 proved to be a fruitful one for the Center. New findings and the start of exciting new missions, which could revolutionize the way we see Earth and the vast universe around us, defined the year. The scientists who played roles in these missions as well as those who worked behind the scenes in vital administrative and engineering capacities tell their stories.*

*IMAGE RIGHT: The Microwave Anisotropy Probe (MAP), a successor to Goddard’s highly successful Cosmic Background Explorer, is collecting enough data to make a map of the entire sky showing the tiny fluctuations in temperature, which reveal clues about the nature, composition and destiny of the universe.*

## Mapping the Early Universe

When Chuck Bennett came to the Goddard Space Flight Center in 1984 as a young graduate from the Massachusetts Institute of Technology, the Cosmic Background Explorer (COBE) was one of the hottest, most exciting missions at NASA. He couldn’t think of anything more professionally rewarding than to peer back in space and time to study the oldest light in the cosmos, the faint background radiation that the Big Bang created between 12 and 15 billion years ago when it created the universe in an unimaginable cauldron.



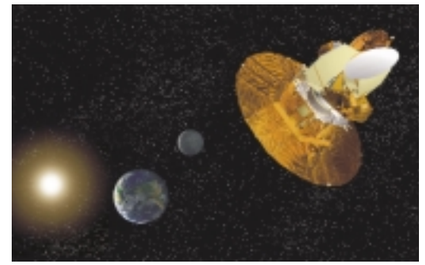
*Chuck Bennett*

Nearly 20 years later, Bennett still wants to study this faint afterglow radiation, which bathes the sky in all directions. Now, however, he’s in the driver’s seat of NASA’s latest cosmological mission. As the principal investigator of the Microwave Anisotropy Probe (MAP), his job is to carry on where COBE left off when it discovered tiny temperature fluctuations in the afterglow—evidence that proved the beginnings of the large-scale pattern of galaxies we see today.

Since the spacecraft’s picture-perfect launch on June 30, Bennett said he and his team, led by Goddard and Princeton University, are well on the way to achieving the mission’s ambitious goals.

Now safely in orbit 1 million miles from home, MAP has checked out perfectly and has begun collecting information about the faint cosmic glow in five wavelength bands. It will collect enough data to make a map of the entire sky, which Bennett expects in December 2002. From this map, scientists will study the patterns caused by the fluctuations in temperature to unravel clues about the nature, composition and destiny of the universe. Because MAP has 30 times greater resolution and is 50 times more sensitive than COBE, astronomers are anticipating even greater results.

In so many ways, MAP is a mission of firsts. Before MAP, Goddard never competed for a mission. In 1995, NASA received 65 proposals for a mid-sized, Explorer-class mission. It selected only two. MAP made the cut. Before MAP, Goddard had never formed such a close partnership with a university to develop a major space mission. Goddard and Princeton relied on each other’s strengths to build successfully a space mission that wasn’t easy to build. And before MAP, 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 has used it as a permanent observing station.



“Like COBE, MAP so far is a huge success for the Center,” Bennett says. “It really is a testament to the engineers here. It really is the hottest thing at NASA.”

## A Hat Trick

Astronomer Tod Strohmayer had a productive year. With NASA's Rossi X-ray Timing Explorer, Strohmayer discerned details about the surfaces of neutron stars and the bizarre physics that abound near the so-called "event horizon," the theoretical boundary of a black hole beyond which nothing can escape—not even light.

In April 2001, he announced the first convincing evidence that at least some black holes actually spin. Theorists had long suspected such a twist. After all, stars and planets spin. Why not black holes? Yet detecting such a physical phenomenon proved dramatically more difficult because black holes have no solid surface to examine.

To see the invisible, Strohmayer used the Rossi Explorer, a satellite built by Goddard and several universities, and found unique flickering patterns in the

*Todd Strohmayer*

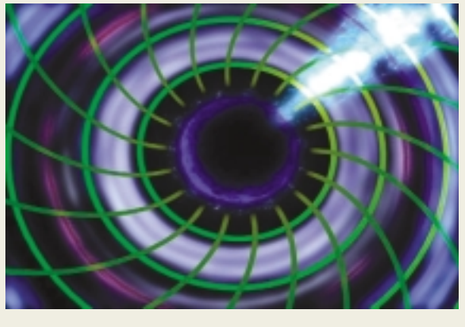
x-ray radiation emitted from hot gas circling very close around a black hole about 10,000 light-years from Earth. He figured that the motions of matter near the innermost stable orbit—the closest orbit a blob of gas can maintain before falling pell-mell into the black hole—caused these patterns or oscillations.

So what followed for Strohmayer was pure math. Earlier optical observations established that the mass of the black hole was about seven solar masses. Applying Einstein's theory of general relativity, Strohmayer calculated that this mass would place the innermost stable orbit at about 40 miles if the black hole was not spinning. However, the rate of oscillation, which the Rossi Explorer determined to be 450 Hz, could only mean that the innermost stable orbit was 30 miles. This black hole had to be spinning, otherwise gas that close would fall in, he determined; and *bingo*, he had made a discovery.

But it wasn't the first for Strohmayer. Just a few months earlier with the Rossi Explorer, he uncovered an unprecedented 3-hour-long thermonuclear burst on the surface of one neutron star, which astronomers describe as a stellar remnant with a mass of between 1.4 and 3 solar masses. These objects collapsed under gravity, causing protons and electrons to smash together to form neutrons. This thermonuclear burst was likely caused by more than a year's worth of stored carbon—the nuclear ash from daily helium explosions—packed so tightly below the neutron star surface that it finally fused and exploded.

And before this, Strohmayer found direct evidence for millisecond spin rates of neutron stars by discovering oscillations during thermonuclear bursts—finding that earned him the 2000 Lindsay award from Goddard.

In the world of sports, which Strohmayer follows because of his avid interest in hockey, three in a row "makes a hat trick." That's the kind of year Strohmayer had.



*These two images are an artist's concept illustrating the difference between a spinning black hole and one that is not spinning. In both images, the central black circle (surrounded by a blue glow), represents the black hole's point of no return, called the event horizon. The surrounding blue and white rings represent hot gas whirling around the black hole on its way to oblivion, much like soap suds swirl around a bathtub drain. The green grid depicts space-time coordinates. Note how the spinning black hole (top image) distorts the space time grid. A spinning black hole modifies the fabric of space-time near it, allowing matter to orbit at a closer distance than if the black hole were not spinning.*



## Pinned by Gravity

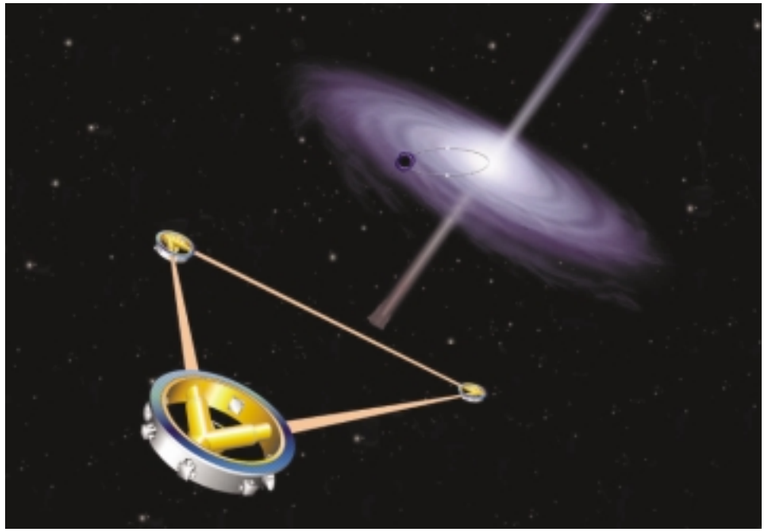
Stephen Merkowitz has spent his entire professional career building sophisticated scientific instruments that measure gravity. It's not an easy undertaking, but nothing compares with what he's doing now.

Just before the start of the fiscal year, he began working on the ambitious Laser Interferometer Space Antenna (LISA) mission—the first space mission to attempt to detect gravitational radiation. Gravitational radiation, also known as gravity waves, is one of the last unproven predictions of Einstein's theory of general relativity and it's essentially ripples in space-time that propagate through the universe at the speed of light, unimpeded by matter.

*Stephen Merkowitz*

Detecting gravity waves will be challenging, but Merkowitz has the know-how and patience to get the job done.

He and his colleagues from the University of Washington hold the record for measuring the force of gravity to its greatest precision. And for LISA, precision is key. The effect of gravitational radiation on matter is miniscule. Like ships on the ocean, all matter, which would include stars, planets and people, bob up and down with each passing gravity wave. Yet the waves alter the distance between objects by no more than a picometer, less than the width of an atom.



Under the current plan, LISA would comprise three satellites in a triangular formation, placed 3.1 million miles apart, but anchored to each other by a laser. A gravity wave would rock each satellite as it passes, altering their distances from each other by about a picometer. Merkowitz is now developing instruments that would detect the tiny distance change across millions of kilometers in space. The mission is planned for early next decade; an engineering test flight could fly in about 5 years.

"Detecting gravitational radiation would be the ultimate reward," said Merkowitz. "The implications are staggering: If they exist, gravity waves would represent a new window to observe the universe, analogous to electromagnetic radiation in all of its forms, from radio waves through gamma rays."

*The LISA mission, which could fly early next decade, will attempt to detect gravitational radiation, one of the last unproven predictions of Einstein's theory of general relativity. Under the current plan, LISA would comprise three satellites in a triangular formation, placed 3.1 million miles apart, but anchored to each other by a laser. A gravity wave would rock each satellite as it passes, altering their distances from each other by about a picometer.*

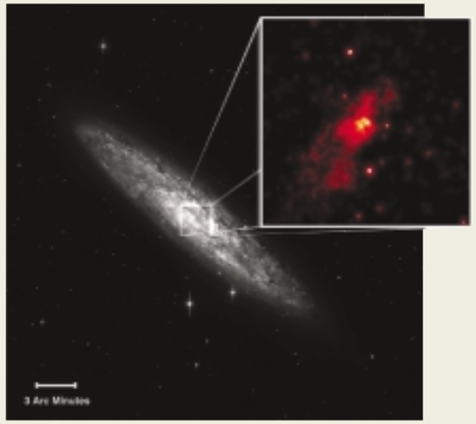
## Looking for a Connection

Some astronomers study black holes, exotic objects that warp space and bring time to a standstill. Others turn to colorful galaxies with the remains of star explosions glimmering like jewels. Kim Weaver has the enviable task of studying both; in fact, she is looking for a connection between the two.

In June, Weaver reported that starburst galaxies—known for their dazzling display of young massive stars and supernova explosions—have a higher proportion of ultra-luminous x-ray sources, which suggests the existence of a new type of black hole. What's interesting about starburst galaxies, she says, is that the bulk of their luminosity comes from outside the core region. In contrast, other types of bright galaxies, such as quasars, emit most of their light from within the core region—a phenomenon called an Active Galactic Nucleus (AGN), likely powered by a supermassive black hole.

Though starburst galaxies and AGN would appear to be completely different, Weaver suspects a connection.

*Kimberly Weaver*




*The Chandra X-ray image (inset) shows the central region of the starburst galaxy known as NGC 253 as compared with the optical view. NGC 253 has at least six so-called ultra-luminous (very powerful x ray) point sources. Chandra shows that four of them are located within about 3,000 light- years from the galaxy's core. This relatively close distance may imply that the ultra-luminous objects—which are usually found slightly farther out—are gravitating towards the center of the galaxy.*

She believes that starbursts may evolve into AGN. Gas expelled from the multitude of star explosions might collide and collapse into intermediate-size black holes, the so-called ultra-luminous x-ray sources that she has observed. These black holes might sink to the center of a starburst galaxy to form a single supermassive black hole. The supermassive black hole, in turn, grows larger as it pulls in more gas from the galaxy core. This would then turn the light source of the galaxy "inside out," making the core bright instead of the disk.

Recently with the Chandra X-ray Observatory, Weaver found evidence of black holes sinking into the core of one starburst galaxy and of nascent AGN activity there. "Could it be that this starburst galaxy is transforming itself into a quasar-like galaxy as we watch," she asks. If so, Weaver's find will have broad implications for galaxy evolution and black-hole formation.

## Hair-Splitting Stars

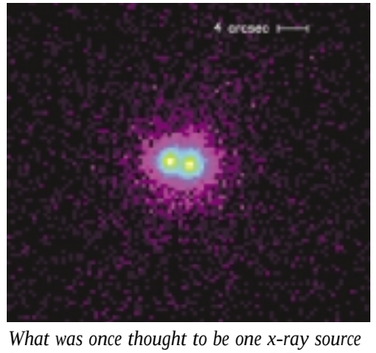
Nick White and Lorella Angelini don't team up often, but when they do, big things happen.

In the 1980s, they worked together on the European Space Agency's x ray astronomy mission (EXOSAT) which laid the foundation for spectacular discoveries to come with the Goddard-led Rossi Explorer mission launched in 1995. In the 1990s, they teamed to establish Goddard's High Energy Astrophysics Science Archive Research Center, and in 2001, they joined forces once again to solve a mystery about a strange binary-star system in the M15 globular cluster that had just about everyone stumped. What they discovered still borders on the bizarre. The object isn't just one binary-star system but two, separated by a hair.

The mystery began in 1984 when scientists, using the Einstein x-ray satellite, discovered M15's first such binary. A neutron star, which is the remains of a once fairly large star, was orbiting a "living" hydrogen-burning star slightly smaller than the Sun. Six years later, with the Japanese Ginga x-ray satellite, astronomers detected an x-ray burst from the region. The Ginga observation indicated that scientists were seeing the surface of the neutron star, while the first observation indicated the neutron star's surface was hidden. It was as if this star system was wearing two faces.

White and Angelini observed the region with the Chandra x-ray Observatory for nearly 6 hours. They discovered two x-ray sources separated by a mere 2.7 arcseconds. That's close, considering that the distance across the pinpoint of light that observers see as Mars here on Earth forms an angle of about 5 arcseconds. It took the exquisite resolving power of Chandra to separate the two binary-star systems.

*Nicholas White and Lorella Angelini*




*What was once thought to be one x-ray source is really two sources separated by 2.7 arcseconds. (The distance across Mars, from our vantage point on Earth, forms an angle of about 5 arcseconds. So imagine a gap smaller than that pinpoint of light from Mars.) The new x-ray source, which Goddard scientists Nicholas White and Lorella Angelini dubbed M15-X2, is likely a neutron star orbiting a faint blue star.*

The broader implication of the Angelini-White discovery is that these types of binaries can be quite common in star clusters, as was theorized but never observed. "We can be certain that globular clusters, with their myriad stars, contain many x ray binary systems," Angelini says. "We should expect many more black holes and neutron stars buried inside."

## A Brave New World for Business

Chief Financial Officer Nancy Abell likens NASA's internal business processes to a crazy quilt, a patchwork of aging mainframes and desktop computers. Although the system works, it is neither up-to-date nor efficient—especially in an era of e-commerce and other Internet-enabled technologies that have revolutionized the business of business.

Under a sweeping initiative now being implemented across NASA, however, that won't be the case for long.

Last year, the Agency began implementing the Integrated Financial Management System at Headquarters and its 10 centers. Once completely implemented in 2008, the system will change the way the Agency collects resumes, manages assets, buys goods and services, makes travel plans, formulates budgets and conducts human resources and accounting. "Virtually every aspect of the space Agency's business practices will be affected," says Abell, who is responsible for overseeing the implementation of its core financial backbone at Goddard and Headquarters. "We're not simply implementing software packages. We're changing how we work. The change will be dramatic."

In fiscal 2001, Goddard phased in the first of nine modules, an automated resume system known as the STaffing And Recruitment System (STARS). A key element is the system's commercial off-the-shelf referral software system that uses optical character recognition and imaging technologies to automatically match skills in applicants' resumes to the skill requirements of specific jobs. Since going live in July, 95 percent of the resumes coming into NASA come by way of STARS.

*Nancy Abell*

The next—and perhaps most critical—phase is Core Finance, the accounting piece of the system that Abell's office began implementing at NASA Headquarters. By 2003, the entire module should be in place at Goddard. The ramifications of this one module are enormous, Abell says. Program and project managers will get more timely access to project costs, which will allow them to be more accountable to decision-makers and lawmakers, she says. But perhaps more exciting is its ability to provide a tool to support full-cost management across the entire Agency—now only possible through a laborious tracking of actual expenses and projected costs.

"It's been a long time coming, but this year, it became truly evident that the new system was really going to come," Abell says. "This system will improve our business processes and give us a tool that moves us into the e-business world. It's exciting. It's going to be a busy year for people in finance."

## Ozone Adventures

For Earth Scientist Anne Thompson, life is a series of ozone adventures.

*Anne Thompson*

Just before the start of fiscal 2001, for example, Thompson and her colleagues traveled to Lusaka, Zambia to measure how biomass burning affected ozone as part of SAFARI 2000, an international research effort aimed at verifying satellite data and understanding Southern Africa's complex environmental interactions.

Thompson almost didn't get what she went to Africa for. A mix-up in international sampling protocols led to a phone call in the middle of the night ordering a halt to the work and a return home. After a week of hard work, Thompson and her colleagues had just gotten their first ozone profile. "When I saw that some of the ozone layers over Lusaka were imported from other countries, I knew that we had to get more soundings." Her sampling team doubled its efforts to get a full set of data before the departure deadline. Looking back, she says, "it's landmark data and well worth the effort it took."

Throughout her stay in Zambia, she says, city residents burned trash, made charcoal for a year's cooking and cleared debris along the roads, with crews systematically torching several hundred meters a day. All this activity added to pollution created from the massive burning taking place in more rural jurisdictions. "We went to study the huge rural fires in that region of Africa," Thompson says, "and we were able to characterize for the first time the impacts of urban burning as well. This is the kind of discovery that keeps you on the track of more ozone measurements."

A few weeks later, Thompson traveled to Germany to oversee ozonesonde chamber tests to calibrate the Lusaka data. (Ozonesonde is short for an ozone sounder or ozone sounding instrument.) In January, she went to Bangkok to plan a global ozone measuring strategy. And, in March, Thompson and her colleagues published a paper in the journal, *Science*, showing that smoke and ozone from biomass fires can travel in different directions as they move across the planet. This finding could help scientists do a better job of tracking pollution and warning people when unhealthy air approaches.

*Scientist Anne Thompson and one of her assistants pose with a scientific balloon, which carried scientific instruments that gathered data on the effects of biomass burning in Lusaka, Zambia. The effort was part of NASA's SAFARI 2000, an international research effort aimed at verifying satellite data and understanding Southern Africa's complex environmental interactions.*

The same month Thompson headed for Southeast Asia and Japan to gather data on global pollution as part of the TRACE-P mission. She and her colleagues were flying 500 feet above the China Sea when the Chinese put a radar lock on NASA's P-3B aircraft. Thompson and the rest of the NASA team survived that episode and went on to discover that the carbon monoxide pollution streaming from China toward the Pacific was far greater than expected, Thompson says. July brought a lecture trip to Nova Scotia and discussions for an international air-sea exchange experiment to be held in 2003.

Thompson wrapped up the year of adventure a little closer to home. While lecturing to a group of Honors students at the University of Maryland College Park in September, a deadly tornado roared past the classroom. She and the students were so absorbed in a demonstration of ozonesonde measurements that they didn't even realize what had happened.

It was just another day in the life of an ozone scientist.

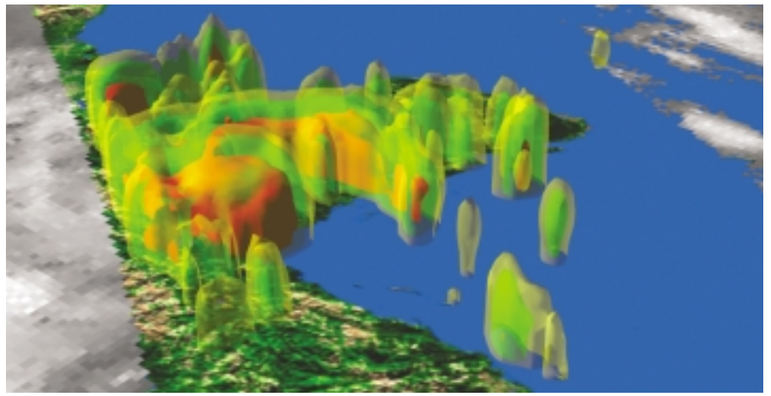
## Mother Knows Best

Marshall Shepherd, who until recently served as the Outreach Scientist for the Tropical Rainfall Measuring Mission (TRMM), says he relied on the services of his mother during his 3 years on the job. "She was my litmus test," he says. If she didn't understand a concept or a rationale for doing something, it was guaranteed that no one else would.

And since he was tasked with explaining the satellite's findings to the media, members of Congress and other lay audiences in down-to-Earth, understandable language, he listened to his mother.

He was on hand when flight controllers boosted TRMM to a higher orbit, which



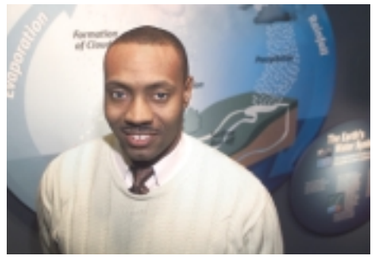


*The image illustrates a cross-section through a tropical storm system. TRMM microwave instruments allow scientists to look at the processes inside a storm that may lead to intensification or more rainfall. Red colors represent areas of heavier rainfall while green colors represent lighter rainfall amounts. The contoured regions illustrate the approximate vertical extent of the precipitating cloud systems in the storms as measured from the spacecraft.*

signified yet another milestone in this fabulously successful mission. It was his job to explain NASA's rationale for performing the maneuver.

"This was a very important thing," Shepherd says. "Just by raising the satellite's orbit from 217 miles to 250 miles above Earth, we've extended the satellite's life an additional 5 to 6 years." With the new orbit, NASA engineers won't have to burn as much fuel to make orbital adjustments to counter the effects of drag and friction at the original orbit. And because TRMM's fuel reserves were running low, NASA had to decide whether to end the mission and prepare for a controlled re-entry or boost to a higher orbit and extend it. For Earth scientists and meteorologists, the decision was easy—prolong TRMM's life.

As with other missions, TRMM has proven to be more valuable than even its most ardent supporters could have hoped, Shepherd says. It confirmed that lightning was more prevalent over land areas than water and that pollution may suppress rainfall—information of keen interest to scientists trying to better understand climate change. TRMM has provided one of the most comprehensive climatologies of global tropical rainfall and has significantly reduced uncertainty in tropical rainfall estimates,



*Marshall Shepherd*

which are critical for assessing climate change and forecasting weather, Shepherd says.

"We found all of these unexpected benefits," Shepherd says. Operational centers like NOAA's National Hurricane Center and the Department of Defense's Joint Typhoon Warning Center routinely used TRMM data for hurricane identification and monitoring. The European Center for Medium Range Weather Forecasting and NOAA's National Center for Environmental Prediction are just beginning to test TRMM data in weather forecasts and models.

With its new lease on life, Shepherd believes TRMM will provide an even longer record of rainfall over the tropics and more precise weather forecasting, which isn't bad for a satellite that was supposed to operate only 3 years. Even his mother understands that.

## The Balloon Lady

Scientific balloons have become commonplace. The NASA Balloon Program at Wallops Flight Facility alone averages about 25 flights each year, lofting these billowing giants a hundred thousand feet above the Earth's surface from such places as Palestine, Texas, Ft. Sumner, New Mexico, and as far away as Australia and Antarctica. Now balloonists would like to try their craft in an alien world, millions of miles from home.

Debbie Fairbrother, a Balloon Technology Manager at Wallops, counts herself as a member of that crowd and has begun planning a demonstration project that she hopes will give her Goddard team an edge to winning future opportunities.

To Fairbrother, one of the few women involved in the field today, balloons are a way to fly an experiment package on

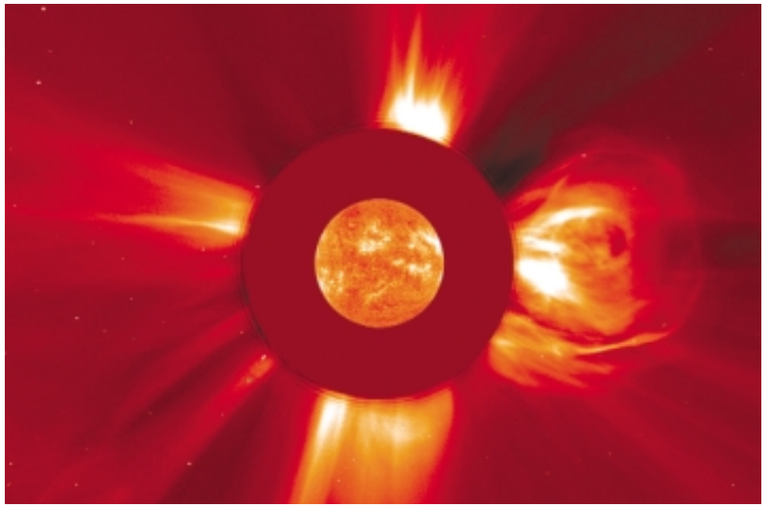
*Debbie Fairbrother*

Mars. “I know balloons,” she says. “You can get better resolution than with an orbiter and more spatial coverage than from a lander or rover. Furthermore, you can have longer duration than from airplanes or gliders. We’re hoping for 7 days, but it’s conceivable that you would get much more.”

Under most scenarios, a Mars balloon would be deployed soon after the spacecraft entered the Mars atmosphere and rapidly inflated from a helium tank as the payload system descended beneath a parachute. Once fully inflated, the parachute and tanks would detach and the balloon and its payload would then fly at a near constant altitude for a few days. But even she says building a balloon capable of doing this will be a challenge.

However, she’s hopeful that the experience gained on NASA’s Ultra-Long Duration Balloon (ULDB) will provide some needed insights as she pursues her goal. The ULDB is a lobed or pumpkin-shaped platform composed of a lightweight polyethylene film about the thickness of ordinary plastic food wrap.

“The technology developments under ULDB have made a Mars balloon feasible,” she says. “The pumpkin design, combined with advanced materials, is making this possible.” However, the Mars balloon presents an added technical twist, she says. “The balloon film will have to be thinner than we traditionally fly, and reducing the weight of every component of the balloon is critical. That’s quite a challenge,” she says.



*In the spring, an active region on the Sun unleashed the biggest x-ray flare on record, definitely more powerful than the famous 1989 flare that disrupted power grids in Canada. The big explosion, which took place near the Sun's northwest limb, hurled a CME into space at a whopping speed of roughly 4.5 million miles an hour. Goddard scientists Nicky Fox and Michael Hesse spend their careers tracking events and attempting to determine their impact on Earth.*

## Watching the Weather…Space Weather, That Is

Sometimes she awakes at 4 a.m. and checks her computer to see if anything happened overnight while she slept. If something did, Scientist Nicky Fox wants to be well prepared for the onslaught of questions she undoubtedly will face when she arrives to work that day.

Fox is a space weather diva, a moniker that a Baltimore-area weathercaster coined to describe Fox’s job with NASA’s International Solar Terrestrial Program managed at the Goddard Space Flight Center. It’s an appropriate title. Fox alerts the scientific community, the media and others when the Solar and Heliospheric Observatory (SOHO) and other satellites detect a solar flare or Coronal Mass Ejection (CME) heading toward Earth.

CMEs are huge bubbles of plasma from the Sun’s outer atmosphere. The equivalent of a hurricane on Earth, these events propel billions of highly charged particles toward Earth at up to 2 million miles an hour. The collision of these particles with Earth’s protective magnetic layer, called the magnetosphere, causes the flickering Northern and Southern Lights, as well as satellite failures, power grid blackouts and radio difficulties. More worrisome, however, are the health risks posed to astronauts. On March 31, NASA’s satellites detected one of the biggest storms of the year, Fox says. Fortunately, it made barely a ripple here on Earth.

*Nicky Fox*

*Michael Hesse*

Given the potential seriousness of these space–weather events, many see a need to predict them before they happen.

That’s where Michael Hesse comes in. In a nondescript laboratory on the Goddard campus, Hesse operates the Community Coordinated Modeling Center, a joint effort between NASA, the Air Force, the National Science Foundation, the Navy and NOAA.

Hesse—one of the scientists Nicky alerts as part of her job—is responsible for developing, testing and evaluating sophisticated computer models that could one day help scientists predict a solar eruption and its effect on geospace. With its solar-terrestrial satellites, including SOHO, Geotail, POLAR, ACE and WIND, NASA is making good progress, Hesse says. “But we’re just in our infancy. We’re where the National Weather Service was 40 years ago.”

In September, the Center took a big step toward achieving its goal, however. It delivered its first model to Air Force Operations, Hesse says. “It was a big milestone for us. We’re learning and establishing a process, and that was an important step forward.”

## “I Liked to Fish”

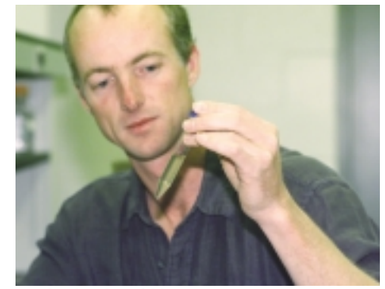
It all started because Michael Behrenfeld liked to fish.

“I remember thinking while waiting for a bite, ‘I wonder what’s going on down there,’” Behrenfeld says, recalling a childhood episode in which he first became truly intrigued by the oceans and the life that they support. His fascination gave way to a career many years later while working on a research vessel that set out to gather data on the effects of ozone depletion on marine life. “That was it,” he says. “I was hooked.”

Behrenfeld is still hooked.

He and his colleagues made headlines in 2001 because of a study that appeared in the journal, *Science*. Using 3 years of observations from the Sea-viewing Wide Field-of-View Sensor (SeaWiFS), Behrenfeld and colleagues described comprehensive global changes in the Earth’s ocean algae and land plants. “This is a period of exploration for us,” he says. “We’ve never been able to see the Earth this way before.”

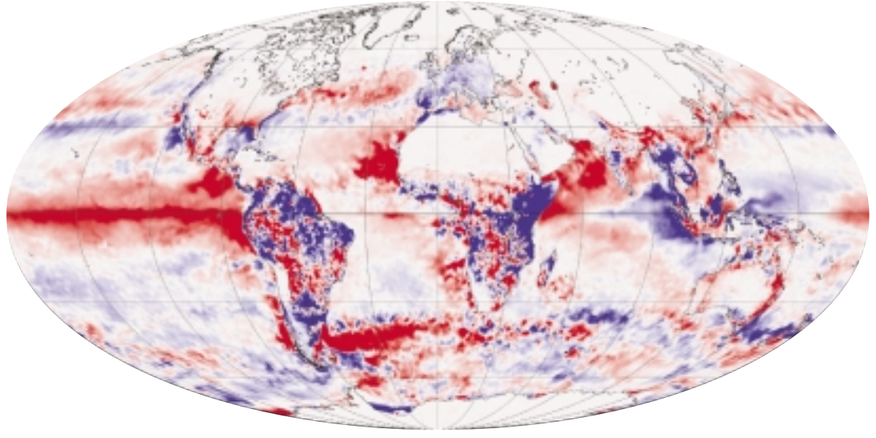
With this record, NASA has more biological data than has been collected by all previous field surveys and ship cruises. In fact, it would have taken a ship



*Michael Behrenfeld*

steaming at 6 knots more than 4,000 years to provide the same coverage as a single global SeaWiFS image.

More important, though, the study gave Behrenfeld and other researchers an opportunity to assess how the concentration of phytoplankton has changed with time and, consequently, how photosynthesis in the oceans has changed. Photosynthesis is the process common



*After 3 years of continuous data collection by the SeaWiFS instrument, NASA has gathered the first record of photosynthetic productivity in the oceans. By monitoring the color of reflected light via satellite, scientists can determine how successfully plant life is photosynthesizing. A measurement of photosynthesis is essentially a measurement of successful growth, and growth means successful use of ambient carbon. Until now, scientists have only had a continuous record of photosynthesis on land.*

to both land and ocean plants that uses sunlight and carbon dioxide to make oxygen and sugars, some of which are later used by animals. If the concentration of phytoplankton changes globally, then it is reasonable to assume that the levels of carbon dioxide absorbed also has changed, which in turn could influence global temperatures.

The study indicates that global plant photosynthesis increased between September 1997 and August 2000. Behrenfeld believes the initial increase was largely due to the response of ocean plants to a strong El Niño to La Niña transition, but the cause of the continued increase during the later portion of the record is not clear. "With 3 years of observations, we can see seasonal changes, but we don't yet have a long enough record to distinguish multi-year cycles, like El Niño, from fundamental long-term changes caused by such things as higher carbon dioxide levels in the atmosphere," Behrenfeld says.

Researchers will continue their quest to find out, however. NASA plans to produce a 5-year record using SeaWiFS observations and extend the continuous biological record with two Earth Observing System (EOS) spacecraft, Terra, launched in 1999, and Aqua, scheduled for launch in 2002.

Though Behrenfeld has an affinity for research cruises, he's also the first to recognize the value of satellite imagery. "Without satellite data, it would be impossible to do what we did. You couldn't send enough ships out there."

## Making Sense of Dust

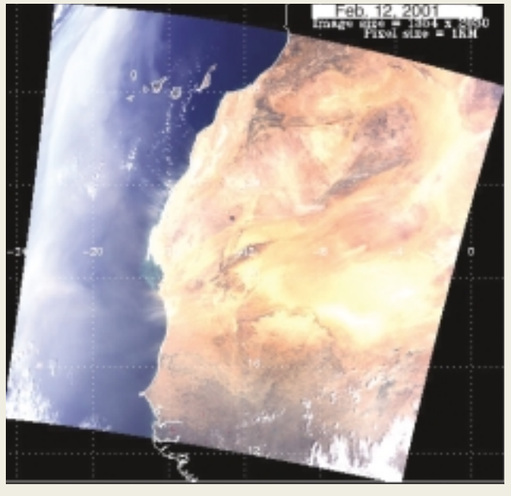
Goddard Senior Atmospheric Scientist Yoram Kaufman had no reason to doubt the computer models. As he said: "Who am I to argue here?"

*Yorum Kaufman*

As it turned out, Kaufman had plenty to argue. Based on two independent remote sensing techniques, one applied to satellite data (Landsat) and one to ground-based data (Aerosol Robotic Network, AERONET), he and his research colleagues from the U.S., France and Israel discovered that the commonly accepted dust-absorption models were inaccurate. The old models, which were based on old laboratory measurements of dust, suggested that desert dust absorbed 10 to 15 percent of the sunlight that hits the dust particles, Kaufman says. "Our new results found dust absorption to be only 1 to 5 percent."

The findings, which Kaufman and his associates reported in the *Geophysical Research Letters* in April, and were meanwhile verified using the new MODIS space data, are significant. This means that the Earth's surface receives less warmth in areas where dust lingers in the atmosphere because the radiation is reflected back into space. "To predict climate change, we need models that understand what's going on," Kaufman explains. "We need to understand the energy balance every day of the year. It's a dynamic system and dust is one of the ingredients."

To reach his conclusions, Kaufman used satellite observations from a 1987 dust storm over Senegal along the coast of western Africa as measured by a French team. He and his research colleagues compared two images from NASA's Landsat 5 spacecraft taken 2 weeks apart; one during a dust storm and another when dust levels had diminished. The difference in the brightness of the solar radiation reflected by Earth's surface showed that nearly all the sunlight in the visible and near infrared part of the spectrum was reflected back into space. Absorption was found only in the blue light, and also is present in the ultraviolet.




*The MODIS instrument flying on NASA's Terra spacecraft took this image of a dust storm along the West African coast on February 12, 2001. The very dry conditions and the resulting dust storm blocked on average 85 percent of the direct sunlight reaching the surface.*

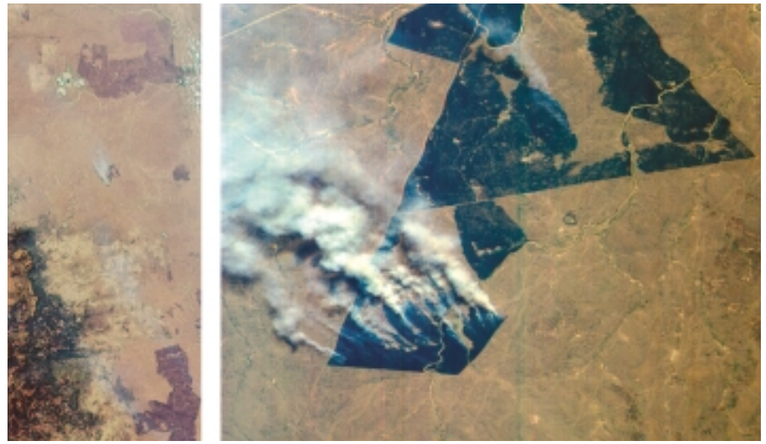
He found a similar ratio of reflected sunlight in the same area 12 years later by looking up from the ground through the dust-filled sky. Instruments on Cape Verde Island, which are part of the AERONET off the Senegalese coast, recorded sunlight reaching the surface, and from that he could infer the absorbing properties of the dust.

Though he's proven the models wrong, Kaufman says it takes time for the scientific community to learn and trust the discovery. At a seminar in the fall, Kaufman says a young graduate student approached him, explaining that he used the old dust transport model and could make little sense of some data he had received from the Tropospheric Ozone Measurement instrument. "I happily pointed him to this paper, and his results made sense," Kaufman says.

## SAFARI 2000

NASA gained more than a terabyte of ground-based, in situ and remote-sensing data during SAFARI 2000, the largest and most aggressive environmental field campaigns ever conducted in Southern Africa. It earned the Agency a generous dollop of goodwill and heightened the visibility of the Agency's Earth-observing satellite program among African nationals, says EOS Senior Project Scientist Michael King.

"We created a lot of goodwill over there and the science is quite unique," King says, looking back on the multidisciplinary program that involved nearly 200 participants from 18 countries, including Canada, Germany, the United Kingdom, the U.S. and several Southern African nations. "NASA has an excellent reputation over there."



*These images, collected as part of an international field, aircraft, and satellite data collection and analysis campaign known as SAFARI-2000, show smoke plumes from fires deliberately set to burn off dry vegetation in northeastern South Africa, near Kruger National Park. SAFARI-2000 is designed, in part, to study the effects of large-scale human activities on the regional climate, meteorology, and ecosystems.*

NASA's EOS project science office sponsored the research campaign, which stands for the Southern African Regional Science Initiative, in part to validate new data products from its Terra spacecraft. Its primary purpose, though, was to study the complex interactions between the region's ecosystems, air pollution, atmospheric circulation, land-atmosphere interactions and land-use changes in Southern Africa. NASA participated in three different phases of SAFARI 2000, and it could not have happened at a better time, King says.

Timed to coincide with the winter fire season in Southern Africa, the research effort during the dry season proved to be more intensive than the previous two SAFARI campaigns in the second half of 1999 and February-March 2000. NASA's Terra and Landsat 7 spacecraft gathered data from space, while researchers worked on the ground and air to augment the observations with NASA's ER-2 high-altitude jet and several ground stations situated in Botswana, Namibia, South Africa and Zambia. "There were a lot of international agreements involved to make this happen," King says.

*Michael King*

Fortunately for the 200 researchers, the biomass burning that normally takes place during the dry season was unusually large, especially in western Zambia, southern Angola, northern Namibia and northern Botswana. Some of the blazes stretched 20 miles long and lasted for days. Compounding the situation were the emissions of coal-fired power plants

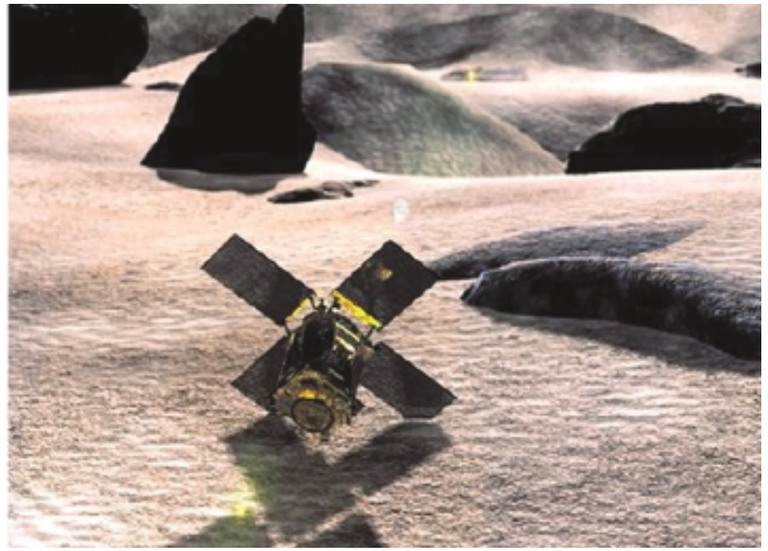
and the metallurgical industries, which taken together produced a “river of smoke” that observers compared to the Kuwaiti oil fires in 1991.

In all, the campaign produced roughly a terabyte of data and invaluable insights into the physical characteristics of aerosols from primary industrial sources. Researchers now will be able to evaluate the relative importance of industrial and other natural and human-induced emissions on the environment. But SAFARI has done something else: It has given NASA a unique opportunity to collaborate with African scientists and establish relationships with them. King is particularly proud of that.

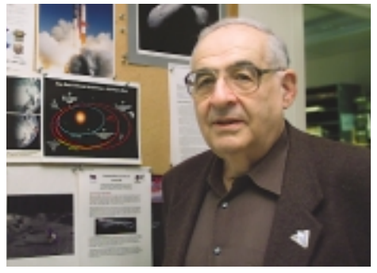
## Eros and Back

On Abraham Lincoln’s birthday, the Near Earth Asteroid Rendezvous (NEAR) spacecraft made history. After spending a year in orbit around Eros, the octagonal-shaped spacecraft made a gentle, three-point landing on the asteroid’s surface—a maneuver it wasn’t even designed to do. To the further amazement of scientists and millions of observers worldwide, the little spacecraft then continued to send back signals.

It was a dream come true. Faced with an unprecedented opportunity to do a little “bonus science,” the science team decided to take advantage of the situation and spend an additional 7 days gathering spectroscopic measurements with the spacecraft’s X-ray/Gamma-Ray Spectrometer (XGRS). The instrument team, led by Jacob Trombka, quickly rewrote and uploaded new software that instructed the spacecraft to begin collecting data on the elemental composition from the instrument’s position just 4 inches above the surface.



*After spending a year in orbit, the NEAR spacecraft amazed scientists and millions of observers worldwide when it gently landed on Eros and continued to send back signals.*



*Jacob Trombka*

The results were spectacular. “This was the first gamma-ray experiment that had ever been done on the surface of a body other than Earth,” recalls Trombka. Although the mission officially ended at 7 p.m. EST on February 28, the work did not end for Trombka. He and his team spent the remainder of the year scrutinizing what they collected and preparing technical papers for publication. NEAR’s more immediate benefits, however, became evident almost immediately.

The mission provided invaluable insights into how mission planners should design and operate future remote sensing XGRS-type instruments, Trombka says. “NEAR is like a feasibility study of how to design an instrument to be used on a rover that could select samples from the surface, look for the presence of water or map the surface for the purpose of future mining.”

But Trombka has no intention of restricting these insights to space missions. He is applying what he learned to a special project with the National Institute of Justice. Under this program, which began in 1996, he is attempting to apply NEAR technology to develop a sensor that could be used by law enforcement officials to solve crimes.

The Oklahoma bombing provides a case in point, Trombka says. Situations like that produce an overwhelming amount of debris that might be hiding valuable evidence. If law enforcement officials had a relatively inexpensive sensor that could detect gunpowder, blood, semen and other physical evidence, they could confidently gather evidence at a fraction of the time and cost. Currently, he says, he’s focusing his attention on gunpowder detection and has begun a test program that uses the same techniques that he applied in the NEAR mission.

The way Trombka sees it, his dual-technology work helps NASA and law enforcement. It’s a win-win situation for everyone.



## Mars Mapped

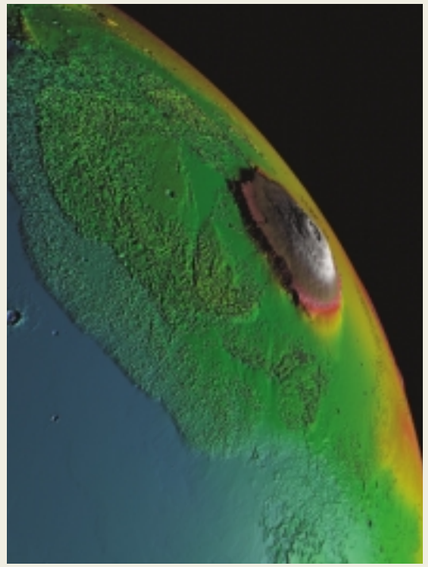
When he’s talking about the Mars Orbiter Laser Altimeter (MOLA), one of the instruments flying on the Mars Global Surveyor, David Smith sounds a bit like a proud papa. The Chief of Goddard’s Laboratory for Terrestrial Physics conceived the instrument, built it and then watched carefully as it collected the most precise topographical measurements ever taken of a solar system body— including Earth.

MOLA's mapping mission began on March 1, 1999. Over 2 years, it took 700 million measurements of the planet, showing topographic details that measure about 3 feet in diameter. Even Earth has not been measured to this level of detail, Smith says. "We’ve contributed to the data set that’s being used by everyone in the community."

The details are remarkable. Pocked with giant-sized craters and towering volcanoes, Mars now looks like a dead planet incapable of supporting life—at least on the surface. But 4 million years ago, that may not have been the case. That’s when Mars lost much of its atmosphere and magnetic field, and gradually its water began to evaporate due to the lack of pressure. "There are no oceans. It hasn’t rained for 4 billion years. But water clearly has been a component of this planet," Smith says.

*David Smith*

*Despite the obvious lack of surface water, Mars, like Earth, changes with the seasons. In this image created from data gathered by the Mars Orbiter Laser Altimeter (MOLA), one of the instruments flying on the Mars Global Surveyor, scientists discovered that as much as 6.5 feet of dry-ice snow can accumulate on the Martian poles.*



Despite the obvious lack of surface water, Mars, like Earth, changes with the seasons. Over the course of a Martian year, which is 687 Earth days, as much as a third of Mars’ tenuous carbon dioxide atmosphere freezes out in the northern and southern hemispheres. As a result of this freezing, snow accumulates on the poles. In fact, MOLA measurements showed that the dry-ice snow reached a maximum depth of about 5 feet to 6.5 feet last year.

The instrument also discovered that the South Pole has a higher elevation than the North Pole by about 4 miles. Smith and his team believe that the slope was present for most of Mars’ history and controlled the surface and subsurface transport of water as indicated by the outflow channels and valley networks evident on the MOLA maps. "Something happened to this planet, and there’s an awful lot we can learn from Mars," Smith says.

Thanks to MOLA, the scientific community knows more about the surface features of Mars than it does of even Earth. Unfortunately, the instrument stopped operating in June. Although it had exceeded its design life, the instrument’s death still saddens the MOLA team. "At first we didn’t want to believe it, but there was no way we could bring it back," Smith says "There was nothing we could have done about it, either."

Although the instrument no longer transmits infrared laser pulses toward the planet to measure the time it takes for the signal to bounce back—a technique that determines the precise elevation of the planet’s surface—MOLA is still playing a role in the Surveyor mission. It also functions as a passive radiometer, and is currently measuring the radiance of the planet’s surface to help determine why some surface areas are brighter than others are, which is a relatively new kind of measurement," Smith says.

" This is a very fine instrument," he says. "Goddard deserves a great deal of credit."

## These Are Not Toys

Earth scientists have an array of platform choices when they fly experiments at high altitudes. They may choose from sounding rockets, balloons and even large uninhabited aerial vehicles (UAV). But their choices diminish considerably when their experiments weigh only a few pounds and are designed for lower altitudes.

But Scientist Geoff Bland, who runs the eXperimental Aerial Platforms (XAP) Lab at the Wallops Flight Facility, has a potential solution, and the community is beginning to sit up and take notice.

For the past year, Bland and his colleagues have tested a series of small, UAVs, which, to the uninitiated, may look a lot like model airplanes. Toys they are not. They are intended to fill a sorely needed gap in flight platforms—particularly for those who wish to fly 1- to 2-pound remote sensing or in situ micro-sensors at up to 30,000 feet, or larger payloads in the 20- to 30-pound range at somewhat lower altitudes. “We are trying to bring affordable, easily fielded platforms to the airborne Earth science research community,” Bland says, explaining the charter of his organization.

In fact, Bland’s laboratory officially “opened for business,” with the maiden voyage of his Xaposoarus UAV, an airborne craft that measures 12.5 feet wide from wingtip-to-wingtip and weighs less than 20 pounds with an atmospheric sensor system. It relies on a tethered blimp to gain initial altitude to conserve onboard battery power used for its twin electric motors and high-tech propellers.

*Geoff Bland*

*These uninhabited aerial vehicles (UAV), under development at the Wallops Flight Facility, are intended to fill a sorely needed gap in flight platforms—particularly those who wish to fly 1- to 2-lb. remote sensing or in situ micro-sensors at up to 30,000 feet or larger payloads at lower altitudes.*

He also hopes to make another type of platform available to the research community. The Evolved Science Platform (ESP) baseline vehicle, with a wingspan of between 10 and 14 feet and capable of carrying 20 to 30-lb. payloads to an altitude of about 10,000 feet, will be tested in the restricted airspace offshore of Wallops Island. Unlike the Xaposoarus, which Bland and his colleagues developed completely from scratch, the ESP aircraft series is based on vehicles built by commercial companies and modified for specific Earth science research needs.

Initial tests will be focused on flying a micro-spectrometer and a “Palm-sized” computer for data collection.

Spectrometers, such as the pint-sized one this UAV will carry, are a low-cost method for collecting data, including the amount of sunlight reflected off the ocean as well as the ocean’s spectra, which indicates chlorophyll levels and other substances. In follow-on test flights, the little airplane will carry an even more sophisticated instrument—a hyper-spectral imager, which can transmit data in near-real time to hand-held computers.

Bland sees a bright future for the Xaposoarus, the ESP and other similar craft that he hopes to develop in the future. Wildfires, thunderstorms, hurricanes, as well as harsh environments like the Arctic or open ocean, are all places these craft could go and deliver critical data to scientists. “We’re simply expanding the options available to the researcher,” he says.



*A plume of smoke is clearly seen in this image of Mt. Etna. EO-1’s Advanced Land Imager took the image on July 22, 2001.*

## Getting Your Money’s Worth

When mission planners asked Steve Ungar whether he’d be interested in serving as the mission scientist on an experimental Earth-observing satellite, called EO-1, he says he didn’t know whether to be thrilled or annoyed. He had never been involved in a validation mission before, and quite frankly, he didn’t know what to expect.

*Stephen Ungar*

"This was very, very new," Ungar now says, reflecting on the pathfinding mission that over the past year has already set new standards on how to build and operate state-of-the-art scientific instruments. "We’re still learning new things about these instruments and what to do with them," he says. In fact, the Agency decided to extend the mission on a self-sustaining basis, which means the satellite will continue to collect data for government and other researchers for as long as it holds out and for as long as the investigators are willing to pay for data collection. Data collection requests and distribution are being handled by the USGS EROS Data Center.

The first Earth Observing mission to be built under the auspices of NASA’s New Millennium Program, EO-1’s primary purpose was to demonstrate and test a set of advanced land-imaging instruments that could be used in next-generation Earth-observing satellites. In addition to the three scientific instruments, engineers loaded the small satellite with innovative engineering enhancements, including new antennas, radiators and solar panels. Futuristic computer software also allows the spacecraft to make its own decisions—”fuzzy logic,” as the engineers like to call it.

Just as innovative was the way the scientific and engineering teams worked together in the initial planning stages, Ungar says. "Here we had an opportunity to get involved in the very beginning. We worked very closely. The project certainly eliminated the cultural gap that sometimes exists between scientists and engineers."

Designed to operate for only a year, EO-1 immediately wowed the community with the quality of its Earth imagery. Scenes of Alaska taken with EO-1’s Advanced Land Imager were considerably better than those taken by Landsat 7 under nearly identical lighting and surface conditions. The Hyperion instrument demonstrated its finesse with images of new spring growth in the mountains of Argentina. And the Linear Etalon Imaging Spectral Array Atmospheric Corrector eliminated the distortion that happens when pictures are taken through the gauzy haze of Earth’s atmosphere.

"There’s no question we got our money’s worth," Ungar says, adding that scientists and engineers are now analyzing EO-1’s results and determining how to incorporate those findings into future missions.

Looking back on the mission, Ungar says he experienced something that he’ll always cherish—the opportunity to truly experiment with the spacecraft’s maximum potential. "We were encouraged to take risks," Ungar explains. "So we experimented with the spacecraft; we turned it around and looked at the moon. You can’t do this with an operational mission. I’m so pleased I was able to participate."

## Free Spirits

Scientist Tom Moore remembers the moment when he first realized that the bright signal in his data wasn't an irregularity, the result of too much light creeping into his instrument flying aboard NASA's Magnetopause to Aurora Global Exploration (IMAGE). He describes it as an "aha" moment that every researcher hopes to experience—at least once.

From his data, Moore discovered the existence of "free spirit" atoms in the solar wind, a stream of electrified and magnetic gas that blows constantly from the Sun at speeds of about 250 miles per second. As their name implies, free spirit atoms do as they please. Electrically neutral—which means that the number of negatively charged electrons balances the number of positively charged protons at the center of the atom—they are not subject to electromagnetic forces and therefore ignore the contours of the magnetic fields in interplanetary space. Such a magnetic field surrounds the Earth.

That's why Moore's instrument, designed to study neutral atoms from Earth, was able to see these relatively rare neutral atoms coming from the Sun. They were impervious to Earth's magnetic field and passed right through the magnetosphere without obstruction, therefore, allowing IMAGE to see them.

Although scientists predicted the existence of free spirit atoms in the solar wind, no one had ever observed them before. Now that Moore and his colleagues have proven their existence, he says the scientific community hopes to use these observations to better estimate the arrival of solar storms, which wreak havoc on Earth-orbiting satellites, power grids and other forms of technology.

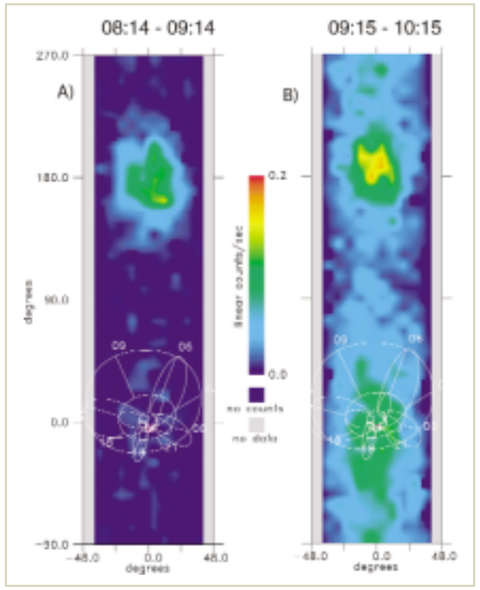
*Tom Moore*

Some solar storms are caused by the collision of billion-ton clouds of electrified gas with Earth's magnetic field. Such clouds, called CMEs, are blasted from near the visible surface of the Sun at speeds of up to 4.5 million mph.

Moore, the IMAGE project scientist, says that though he saw the bright signal, he spent literally months checking and rechecking the data. "When I saw the brightening in the data, I scurried off to see what happened in interplanetary space," Moore recalls. "Sure enough there had been a CME, which meant that the signal couldn't be a light leak."

Scientists also believe that CME clouds carry a higher proportion of neutral atoms than regular solar wind because they come from near the solar surface, which is much cooler than the solar corona, the source of the solar wind. With less heat, fewer atoms will lose their electrons, and therefore more neutral atoms will be carried within a CME cloud. As it races through space, the CME cloud slows down because it plows into the slower solar wind and its magnetic field. Because free spirit atoms can't feel electromagnetic forces, they continue on their journey at the original speed.

This leads solar scientists to believe that a burst of neutral atoms should appear in Earth's upper atmosphere well before the arrival of the CME. "So far, we've been unable to find any CME precursor. But we have found that the neutral solar wind is 100 times stronger on one side of the solar system than on the other. This tells us that the neutrals are not coming from the Sun, but are formed when the solar wind is partly neutralized as it travels to us through the galactic gas in our solar system. So now, we are beginning to study the flow of material from outside our solar system."




*These images, taken 1 hour apart, show the electrically neutral atoms in the solar wind as detected by NASA's IMAGE spacecraft. The innermost white circle at the bottom center of each photo represents the Earth to scale, and the surrounding traces represent the Earth's magnetic field lines at four local times. The false colors represent the intensity of neutral atoms entering the LENA instrument, with red denoting the highest intensity and blue the lowest. Note the bright, colorful patch in the top center of both photos. This corresponds to the Sun's direction and the burst of neutral atoms streaming off the Sun in its solar wind. The right image was taken as a CME rammed into the Earth's magnetic field, and the amount of neutral atoms detected increased correspondingly.*



# Working with Goddard

*The Goddard Space Flight Center is a premier research facility, home to thousands of scientists, engineers and other professionals of different backgrounds and traditions. The people of Goddard have dedicated their professional careers to exploring Earth and the cosmos, creating world-class technology and sharing their knowledge and experiences with others. The following pages provide a glimpse of the work that they do and how their contributions affect those who live nearby and beyond.*

## A Year in Launches: New Spacecraft Launched to Study Earth and Space

In fiscal 2001, Goddard deployed nine missions ultimately aimed at expanding scientists' understanding of our home and our universe.

**HETE-2**

A new gamma-ray burst mission, the High-Energy Transient Explorer (HETE-2), separated from a Pegasus rocket about 12 minutes after launch on October 9, 2000, from the Kwajalein Missile Range in the Marshall Islands. HETE-2 is a multinational collaboration and is designed to locate with pinpoint accuracy hundreds of gamma-ray bursts, the most energetic events in the universe. The satellite then relays the information in real-time to space- and ground-based optical radio observatories.

**EO-1/SAC-C**

Two new Earth orbiting missions, EO-1 and SAC-C, were launched from the Western Test Range at Vandenberg Air Force Base, California, on November 21, 2000. EO-1, which Goddard developed to test a set of advanced land-imaging instruments, was deployed first by a Delta 7320 rocket into a 438-mile orbit approximately 60 minutes after launch. Thirty minutes later, Argentina's SAC-C, which observes land and coastal environments and tests new remote sensing technologies, separated from the Delta rocket into a similar orbit. NASA has extended the life of EO-1, which originally was slated to operate for 1 year. SAC-C has a mission life span of 4 years. NASA is one of six international partners involved with the SAC-C mission.

*EO-1 captured this image of the Baltimore area on August 2, 2001.*

**TopHat**

TopHat, an innovative hat-shaped astronomy experiment that sat on top of a balloon, launched successfully from McMurdo Station, Antarctica, on January 4, 2001 to collect light from the cosmic microwave background radiation, which formed 300,000 years after the Big Bang—long before the creation of stars and galaxies. Observing microwave background enables scientists to understand the history of the universe as well as its future. Built in collaboration with the Goddard Space Flight Center, the University of Chicago, University of Wisconsin and the Danish Space Research Institute, TopHat measured the clumpiness of matter when the universe was very young. Previous balloon experiments determined that the universe is geometrically flat and that it will expand forever.

**Ultra-Long Duration Balloon**

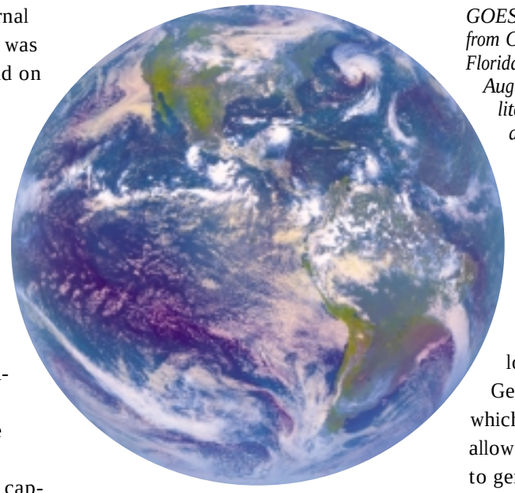
NASA ended the March 10, 2001 launch of the Ultra-Long Duration Balloon mission from the Northern Territory of Central Australia. The balloon, the largest single-cell, super-pressure balloon ever flown, reached its desired float altitude of 112,000 feet before a NASA operations team decided to bring

it down because the balloon's internal pressure was less than expected. It was supposed to travel around the world on the fringes of space.

**MAP**

The Microwave Anisotropy Probe (MAP) lifted off on schedule aboard a Delta II rocket from Pad B at Cape Canaveral Air Force Station in Florida on June 30, 2001 beginning a mission scientists hope will determine the content, shape, history and the ultimate fate of the universe. The satellite, a partnership between the Goddard Space Flight Center and Princeton University, is designed to capture the afterglow of the Big Bang, which comes to us from a time well before any stars, galaxies or quasars existed. Science observations will take place from MAP's L2 orbit, which is four times farther from the Earth than the Moon in the direction opposite the Sun, or about one million miles from Earth. MAP is the first spacecraft to use an L2 orbit as an observing station.

*The MAP satellite is up, up and away on its journey to the beginning of time. NASA's Microwave Anisotropy Probe launched successfully on June 30, 2001, from Cape Canaveral aboard a Delta II rocket. The satellite will study the first light of the universe—the afterglow of the Big Bang—from an era long before the first stars and galaxies appeared.*



*GOES-12 was launched on July 23, 2001 from Cape Canaveral Air Force Station, Florida, and achieved geostationary orbit on August 12. It is the first of the NOAA satellites equipped with a solar x-ray imager, an instrument that can detect solar storms.*

**GOES-12**

GOES-12, a geostationary weather satellite and the first to carry a sophisticated operational instrument for detecting solar storms, sent back a clear, crisp image from its vantage point 22,300 miles above Earth's surface just a few weeks after its launch on July 23, 2001 from Cape Canaveral Air Force Station in Florida. The Geostationary Operational Environmental Satellite (GOES) spacecraft—the fifth of five advanced weather satellites operated by NOAA—takes images of clouds, measures temperature, reads the amount of moisture in the atmosphere, and, with its solar x-ray imager, monitors disruptions on the Sun. NOAA and the U.S. Air Force will use the images to forecast the intensity and speed of solar disturbances that could destroy satellite electronics, disrupt long-distance radio communications or surge power grids. It is being stored in orbit and will replace either GOES-8 or GOES-10 as needed.

**STS-105**

Space Shuttle Discovery lifted off on August 10, 2001 carrying a number of small payloads that flew as part of the Shuttle Small Payloads Project, managed by Wallops Flight Facility. Onboard were Simplesat, a prototype satellite designed to demonstrate Global Positioning System attitude control and payload-assisted fine pointing, and Get-Away Special canister G-780, which contained an experiment that allowed Minnesota high school students to germinate Vicia Faba bean seeds and observe root-cell growth in a microgravity environment. In addition, Discovery flew Space Experiment Module (SEM)-10, which contained 11 experiments developed by school-age children from across the country. The experiments studied everything from the effect of space travel on plants and different types of fabric and adhesives to testing the feasibility of using a laser to communicate in space.

**QuikTOMS**

The QuikTOMS ozone monitoring satellite, launched on September 21, 2001 aboard a Taurus rocket from Vandenberg Air Force Base in California, was lost due to a rocket failure. Initially, the launch went off as planned, but separation problems occurred between the first and second stages about 83 seconds into the flight and the rocket failed to deliver QuikTOMS and another payload to their proper orbit. The loss, though disappointing, does not hinder the Agency's capability to measure ozone. Currently, the orbiting TOMS Earth Probe satellite is continuing its observations and NASA plans to launch the EOS-Aura satellite in 2003 to assure the continuity of these critical ozone measurements.



**NASA Donates Hubble Hardware**

The Hubble Space Telescope's original Wide Field and Planetary Camera, which astronauts removed during the 1993 servicing mission, and its backup primary mirror now grace a new exhibit at the National Air and Space Museum. NASA released the hardware to the museum's new "Explore the Universe" exhibit, which showcases astronomy and astronomical discoveries.

## Innovations in Information and Engineering Technology

NASA cannot explore the Earth and the heavens without first building world-class spacecraft, equipping them with cutting-edge information technologies that hasten the pace and reduce the cost of delivering data to researchers worldwide and creating innovative ways to showcase and interpret that data. The following are a few examples of the technologies Goddard pursued and how it makes scientific data available.

**BAT**

Goddard received a very large delivery of a very small item critical to the development of the Goddard-built Burst Alert Telescope (BAT), one of three telescopes flying on NASA's Swift Gamma-Ray Burst Explorer slated for launch in 2003. To be exact, nearly 40,000 thumbtack-sized gamma-ray detectors arrived at the close of the fiscal year. These tiny cadmium-zinc-telluride (CZT) detectors measure 4 millimeters by 4 millimeters and represent the backbone of BAT, which will observe and locate hundreds of gamma-ray bursts per year. The arrival of these tiny detectors represented a milestone for both the Swift mission and the development of CZT detector technology. Each CZT detector will be fitted onto the BAT array in the form of 128 modules each containing 256 detectors, totaling 32,768 (leaving about 7,000 spare detectors for replacement), making the telescope the largest Goddard has ever built.

**Daley, SGI Supercomputer**

In the summer, Goddard's Data Assimilation Office and the Goddard Institute of Space Studies received an addition to their computing prowess in the form of the 512-processor SGI Origin 3800 supercomputer, which is among the most powerful of its kind. With this computer—made up of 512 computer processors that share a128-part memory—NASA will be able to double the amount of data it ingests to 800,000 observations daily. Further enhancing this formidable processing power is the machine's multi-level parallelism software developed by the Ames Research Center. These twin

### 2002 Missions

SeaWinds (ADEOS II)

Aqua (PM)

CONTOUR

Galaxy Evolution Explorer

Gravity Recovery and Climate Experiment, Pathfinder

High-Energy Solar Spectroscopic Imager

STS-109, Hubble Space Telescope Servicing Mission 3B

International Gamma-Ray Astrophysics Laboratory

NOAA-M

STS 107 (FREESTAR)

Solar Radiation and Climate Experiment

Tracking and Data Relay Satellite I

Tracking and Data Relay Satellite J

In Appreciation…

**THE EXTREME ULTRAVIOLET LIGHT MISSION COMES TO AN END**

After 8 years in orbit—more than twice its planned lifetime—the Extreme Ultraviolet Explorer (EUVE) stopped operating in December 2000. The bantam astronomical satellite opened a new window on the cosmos by observing extreme ultraviolet light, a form of radiation that no one had thoroughly explored until its deployment in June, 1992.

Before NASA launched EUVE, many scientists believed the thin gas between the stars, known as the interstellar medium, would block extreme ultraviolet light. That proved not to be the case. Rather than seeing only a couple dozen nearby objects as many expected, EUVE observed more than 1,000 sources, including more than 3 dozen objects outside our galaxy, making our view of the cosmos more complete.

*SGI Origin 3800 Supercomputer*

*Glass-Forming Oven*

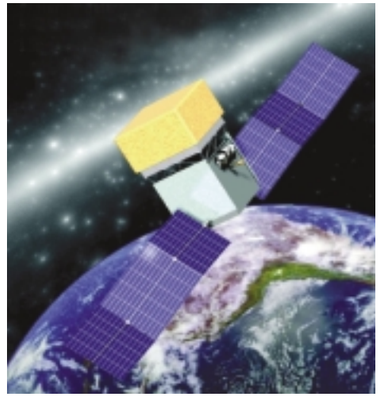
attributes allow the Data Assimilation Office and the Goddard Institute of Space Studies to run climate models four times faster and at double the resolution. The computer is known as Daley in honor of Roger Daley, a leading data assimilation scientist who died in August.

**Glass-Forming Oven**

After a campus-wide search, scientists finally found a new home for the latest addition to their laboratory—a 15,000-pound oven that is critical for forming nested glass cones to be installed inside Constellation-X, a team of powerful x-ray telescopes slated for launch in 2010. The oven can reach temperatures of 2,000º Fahrenheit and is so precise that at any given location, engineers and scientists can get the exact temperature anywhere in the oven. To form these nested circles of extremely thin glass, technicians will place sheets of glass over already-formed molds or mandrels placed inside the oven. The glass heats and forms over the molds. Once in the proper shape, technicians then coat the glass with a highly reflective material designed to focus the highly illusive x ray.

**GLAST**

Scientists successfully tested a key instrument for the next-generation Gamma-ray Large Area Space Telescope (GLAST), which is set to launch in 2006 to study celestial gamma rays, particles of light millions to billions of times more energetic than visible light. Using a 29 million-cubic-foot NASA scientific balloon launched from Palestine, Texas, scientists successfully tested a working prototype of the much-larger detector that will fly on GLAST. The test ran for 3 hours at an altitude of 127,000 feet, which is above 99.5 percent of the atmosphere. GLAST is an international collaboration of astrophysicists and particle physicists, with funding from NASA, the U.S. Department of Energy and agencies in France, Germany, Italy, Japan and Sweden. The National Scientific Balloon Facility, operated for NASA by New Mexico State University, managed the balloon launch.



*Scientists successfully tested a key instrument for the next-generation Gamma-ray Large Area Space Telescope, shown here in this artist's rendition. The satellite is slated to launch in 2006 and will study celestial gamma rays.*

**NEpster**

A popular online music file-sharing service inspired Goddard's NEpster service, which went live 1 month after the Earth and Space Data Computing Division conceived the idea in December 2000. The NEpster system, which stands for NPP ESTO Portal for Science, Technology and Environmental Research, serves as a virtually connected network of real-time Earth science data and products for anyone who has access to the Internet and is willing to share remote sensing data with others. The first phase of NEpster's implementation focused on accessing and managing real-time data from as many ground system sites as possible worldwide. Phase two will add the ability to access MODIS and other instrument direct broadcast data archives through the Goddard Distributed Active Archive Center.

**Assuring Mission-Critical Software: Independent Verification and Validation Facility**

As NASA becomes increasingly more dependent on complex, highly sophisticated mission-critical software, it becomes more important that the Agency mitigate potential problems before the missions fly. The Goddard-managed Independent Verification and Validation Facility in Fairmont, West Virginia, provides that assurance.

Founded in 1993, the facility is still evolving and growing. In June, Nelson H. Keeler assumed overall management of the facility, and in early September, the facility co-hosted with the NASA Office of Safety and Mission Assurance the first Annual Software Assurance Symposium. The conference featured presentations by principal investigators who participated in the Software Assurance Research Program managed by Independent Verification and Validation Facility in fiscal 2001.

## People Making a Difference

Institutions evolve and change as reflected by the people who lead them. During the fiscal year, the Center experienced a number of personnel changes. Dr. Franco Einaudi was named the new Director of the Earth Sciences Directorate and Dr. Jonathan Ormes, who had been serving as the Acting Director for the Space Sciences Directorate, was officially named its Director. Christopher Scolese, who served as the Deputy Director of Flight Programs and Projects, was named Deputy Associate Administrator for the Office of Space Science and was succeeded by Phil Sabelhaus. As the year drew to a close, Center Director A. V. Diaz named Charles Vanek to a newly created post as Assistant Director for Safety and Security and Wentworth O. Denoon as the Director, Office of Systems Safety and Mission Assurance. Milton Halem, former Chief of the Earth and Space Science Data Computing Division and the Center CIO, and John Hrastar, Director of Systems, Technology and Advanced Concepts Directorate, retired. At Wallops Flight Facility, Dr. Arnold Torres, Director of Suborbital and Special Orbital Projects since January 1995, retired at the end of 2001.

**Awards and Recognition**

People make the Goddard Space Flight Center a world-class research facility, and in fiscal 2001, several employees were recognized by external organizations for their contributions to science and engineering. These are a few who received recognition.

Jim Hansen, Chief of the Goddard Space Flight Center's Goddard Institute for Space Studies in New York, NY, was one of this year's recipients of a $250,000 Heinz Award. The award, bestowed annually by the Heinz Family Foundation, honors the memory of Sen. John Heinz, R-PA, who died in a plane crash in 1991. The award is given in recognition of people who enhance the lives of others. In announcing this year's winners, the Heinz Award cited Hansen "for his exemplary leadership in the critical and often-contentious debate over the threat of global climate change."

*Jim Hansen*

The American Meteorological Society bestowed on Goddard's Chief Scientist for Meteorology, Joanne Simpson, the

**Fifteen Minutes of Fame**

Supposedly everyone gets to experience at least 15 minutes of fame. Goddard chemist Jeanette Benavides already has used up her allotment and everyone else's, too.

*Jeanette Benavides*

The Costa Rican native, who analyzes and researches new materials used to build space-hardy spacecraft and instruments, has made quite a name for herself in her homeland. It started about 4 years ago when the Costa Rican Institute of Technology invited her to spend a week meeting with the country's scientists and engineers and visiting schools. It has since snowballed.

One of the country's high schools has named a chemistry lab after her and the Ministry of Science and Technology named its 2001 national science fair in honor of her. When she visits Costa Rica, newspaper and television reporters seek her out as they would a rock star.

Benavides takes it all in stride. "People are fascinated by NASA," she says, adding that she's particularly touched by the letters she receives regularly from students who pursued scientific careers because of her. "It's so moving to learn that I've inspired someone," she says.

*Joanne Simpson*

*Pen-Shu Yeh*

Charles F. Anderson Award in recognition of her extraordinary contribution to promoting educational outreach, educational service and diversity within the Society and the broader community. Simpson, the former project scientist for TRMM, was the world's first woman to obtain a Ph.D. in Meteorology. Throughout her long and distinguished career, Dr. Simpson has been instrumental in promoting diversity within the Society and the greater scientific community and for mentoring young professionals and guiding them toward successful careers.

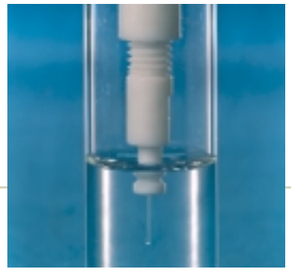
Women in Aerospace, a Washington, DC-based organization dedicated to expanding women's opportunities in the aerospace community, awarded Pen-Shu Yeh an "Outstanding Achievement Award" for her new data compression invention, which has improved the processing of Hubble Space Telescope images and data from other missions. Congresswoman Connie Morella, whose district includes Goddard, presented the award to Dr. Yeh.

**Inventors of the Year**

Goddard's John Kolasinski, a Senior Aerospace Technology Engineer, and Alexander Coleman, a Senior Electronics Technician at Wallop's Flight Facility, won the NASA Government Invention of the Year award for 2000 for their Optical Fiber Cable Chemical Stripping Fixture.

The device, which has been used on several NASA spacecraft, including the X-ray Timing Explorer, TRMM, MAP, Earth Observing-1 and the Hubble Space Telescope's solid state recorder, removes coatings surrounding tiny optical fibers. Traditional coating removal techniques often nicked or scratched the glass fiber. The new tool reduces the likelihood of that happening.

The device would benefit anyone who builds fiber optic cables. By some estimates, telecommunications technicians install close to 200 million feet of fiber-optic cable each year at a typical cost of $30 per foot.



*The award-winning Optical Fiber Cable Chemical Stripping Fixture chemically removes the protective coatings on tiny optical fiber cables, which are made of glass and measure about the width of a human hair. In the image, the fiber optic cable is installed in the device and the end of the cable is then immersed in the chemical solution, which will dissolve the cable's acrylic coating.*

**Transferring Technology**

Senior Fellow and Chief Scientist for Oceanography Norden Huang won a prestigious technology transfer award from the Federal Laboratory Consortium for a groundbreaking technology he created to study ocean waves.

Huang cooperated with the New Jersey-based Princeton Satellite Systems Inc. to combine his method with the Hilbert Transform to create the Hilbert Huang Transform. This groundbreaking technology is the first to analyze nonlinear events, such as earthquakes, heart arrhythmia and variations in global temperatures.

The award recognizes laboratory employees who demonstrate excellence in transferring a technology developed by a federal laboratory to the commercial marketplace.

*Norden Huang*

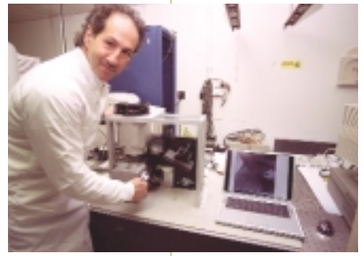
**Celebrating Workforce Diversity**

The Diversity Dialogue Project, one of several programs that the Goddard Diversity Council established in 2000 to promote workforce diversity, involved more than 70 employees who for 5 months this fiscal year met in small groups to discuss their differences. More than 90 percent of participants viewed the project favorably. Many reported that through this exercise they achieved a deeper understanding of diversity and that the program helped them identify behaviors that promoted mutual respect for different points of view. The participants agreed that the Center should hold follow-on sessions.



**Building a Better Detector**

Before 1990, no one had built large-format photodetector arrays that could operate in the far infrared—the wavelength band necessary for understanding climate changes and the events influencing it. That was before Instrument Technology Center Chief Dr. Murzy Jhabvala teamed with other NASA and government agencies and private industry to produce the first Quantum Well Infrared Photodetector arrays, known as QWIP.



Murzy Jhabvala

QWIP, a technology that earned Jhabvala a spot in the Space Foundation's Space Technology Hall of Fame, is a complicated solid-state detector that involves sandwiching gallium arsenide chips between silicon wafers and connecting them with indium connectors. The team installed the technology onto an aircraft, which then flew along the coastal regions to test QWIP's remote sensing capabilities. It has since flown successfully on several aircraft missions.

## Assuring a Healthy Bottomline

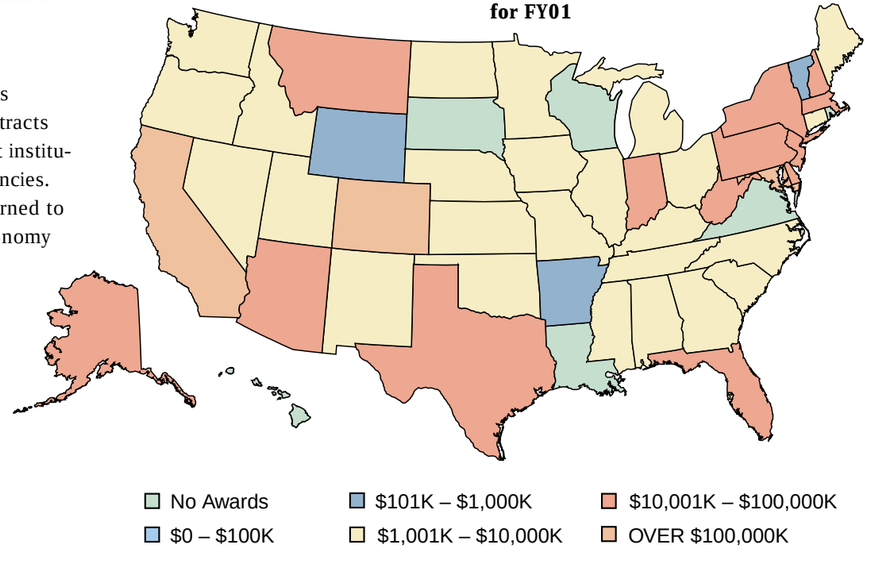
The Goddard Space Flight Center contributes significantly to the local and national economy because it buys goods and services needed to perform its missions. Through grants and other programs, it also promotes small businesses whose ideas and innovations offer promise not only to the commercial world but also to NASA.

**Contract Obligations**

The biggest portion of Goddard's budget is obligated through contracts with commercial firms, nonprofit institutions and other government agencies. Ultimately, these dollars are returned to the local, state and national economy in the form of gross output, sales, the purchase of goods and services and employee income.

In fiscal 2001, Goddard obligated 58 percent of its budget, or $1.3 billion, to commercial companies, 28 percent to educational institutions, 10 percent to non-profit organizations, 7.2 percent to other government agencies and a half percent to organizations geographically outside the U.S.

**Total Prime Contract Awards for FY01**



**Industry Partners At-a-Glance**

The five companies listed below were Goddard's top business contractors in fiscal 2001. The following briefly describes their work at the Center.

LOCKHEED MARTIN

Eight Lockheed Martin Corporation companies held 33 contracts valued at more than $2.5 billion. These companies employ 250 people in the Goddard geographical area. They design and build instruments, spacecraft, ground systems and conduct flight operations and launch services. Their combined efforts amounted to $164.1 million in fiscal 2001.

Raytheon

As the prime contractor of the Earth Observing System Data and Information System Core System program (ECS), Raytheon Information Systems Co. received $127.1 million in fiscal 2001. The ECS provides the infrastructure required to perform Earth science data planning and scheduling, command and control, product generation, information management, data archiving and distribution.

BOEING

Boeing Satellite Systems, formerly known as Hughes Aircraft Co., is in the number three position due to two contracts building the next-generation Tracking and Data Relay Satellites and the second-generation GOES. In fiscal 2001, Goddard obligated $104.1 million for the work.

SWALES AEROSPACE

In 2001, Swales Aerospace, a small employee-owned business, ranked fourth, with eight contracts valued at $92.3 million. In addition to offering engineering services, Swales provides full-service solutions for small satellite missions and offers a broad range of structural- and thermal-management systems and flight hardware.

QSS

In 1994, QSS Group, Inc. won its first support-services contract at Goddard. Since then, the company has grown to become Goddard's largest minority contractor, with 500 on- and off-site professionals who support the Center in aerospace science and engineering services as well as in systems, software and IT support.

| State | Total ($K) |
|---|---|
| Alabama | $6,723 |
| Alaska | 15,436 |
| Arizona | 36,549 |
| Arkansas | 819 |
| California | 365,728 |
| Colorado | 104,047 |
| Connecticut | 4,376 |
| Delaware | 1,477 |
| District of Columbia | 11,091 |
| Florida | 18,333 |
| Georgia | 3,525 |
| Hawaii | 15,289 |
| Idaho | 3,167 |
| Illinois | 8,401 |
| Indiana | 50,101 |
| Iowa | 3,539 |
| Kansas | 1,442 |
| Kentucky | 1,573 |
| Louisiana | 2,429 |
| Maine | 1,614 |
| Maryland | 1,027,278 |
| Massachusetts | 56,523 |
| Michigan | 7,420 |
| Minnesota | 3,884 |
| Mississippi | 1,004 |
| Missouri | 4,626 |
| Montana | $11,247 |
| Nebraska | 1,925 |
| Nevada | 1,704 |
| New Hampshire | 12,292 |
| New Jersey | 53,912 |
| New Mexico | 9,624 |
| New York | 33,108 |
| North Carolina | 3,814 |
| North Dakota | 2,100 |
| Ohio | 7,999 |
| Oklahoma | 5,120 |
| Oregon | 6,532 |
| Pennsylvania | 20,571 |
| Rhode Island | 2,801 |
| South Carolina | 6,385 |
| South Dakota | 1.313 |
| Tennessee | 3,770 |
| Texas | 46,544 |
| Utah | 3,609 |
| Vermont | 587 |
| Virginia | 112,648 |
| Washington | 9,583 |
| West Virginia | 50,676 |
| Wisconsin | 9,088 |
| Wyoming | 252 |
| TOTAL | $2,173,598 |

**Geographical Distribution Summary for FY01. Obligations by State, Place of Performance**

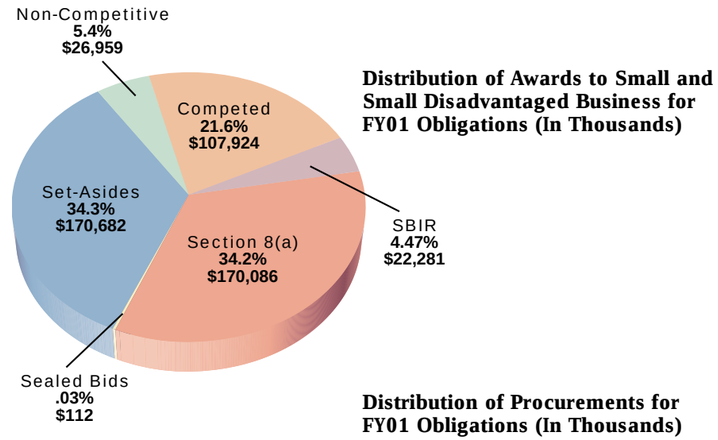
**Goddard Contractors Win George M. Low Award**

Two Goddard contractors—Raytheon ITT in large business services and Swales Aerospace in small business product—won NASA's highest honor for quality and technical performance, the George M. Low Award. It was the second year in a row that Goddard took two out of three Low trophies. Also, ManTech International won a runner-up finalist plaque. NASA Administrator Daniel Goldin presented the awards May 10.

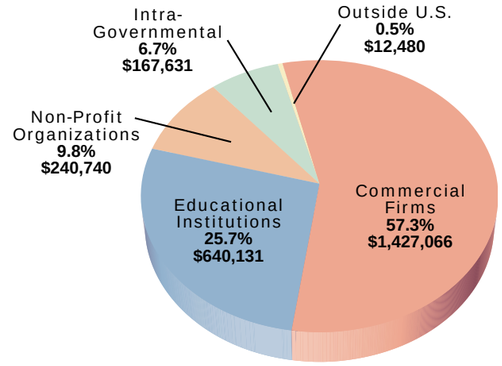
**Supporting Small and Disadvantaged Businesses**

Supporting small businesses, including those owned by disadvantaged persons and women, is a NASA priority. In fiscal 2001, the Center obligated $526 million to small businesses, up from $424 million in fiscal 2000.

The Agency also supports small business through its Goddard-managed Small Business Innovation Research (SBIR) and Small Business Technology Transfer (SBTT) programs. In fiscal 2001, the Goddard selected 325 research proposals under Phase 1 of the SBIR and SBTT programs and 27 research proposals for negotiation under Phase 2.



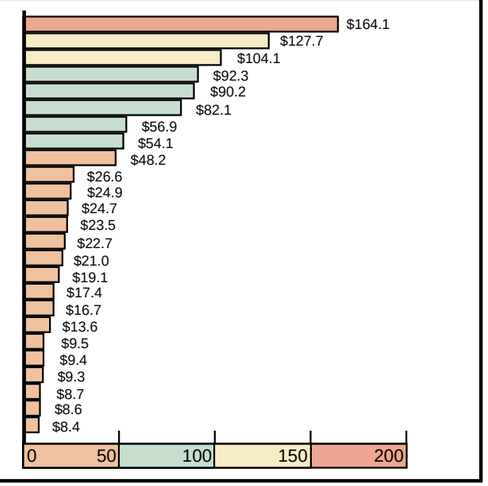

**Distribution of Awards to Small and Small Disadvantaged Business for FY01 Obligations (In Thousands)**




**Distribution of Procurements for FY01 Obligations (In Thousands)**

**Top 25 Business Contractors for FY01**

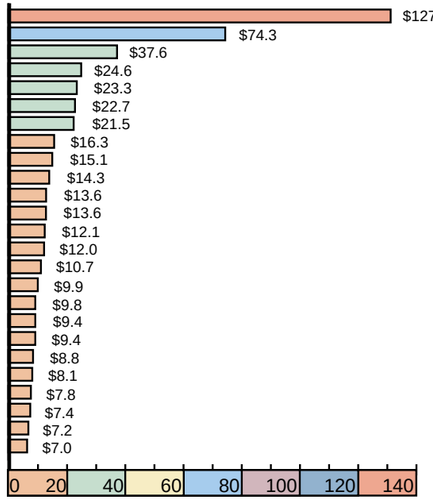
| FY 01 | FY 00 | Company | Number of Contracts | Millions of Dollars Obligated |
|---|---|---|---|---|
| 1 | 1 | Lockheed Martin Corp. | 33 | $164.1 |
| 2 | 2 | Raytheon Information Systems Co | 1 | $127.7 |
| 3 | 4 | Hughes Aircraft Company | 3 | $104.1 |
| 4 | 6 | Swales & Associates, Inc. | 8 | $92.3 |
| 5 | 5 | QSS Group, Inc. | 4 | $90.2 |
| 6 | 3 | TRW, Inc. | 10 | $82.1 |
| 7 | 14 | Science Systems Applications | 18 | $56.9 |
| 8 | 7 | Ball Aerospace & Tech. Corporation | 19 | $54.1 |
| 9 | 9 | ITT Corporation | 5 | $48.2 |
| 10 | 11 | NSI Technology Services Corporation | 2 | $26.6 |
| 11 | 35 | Averstar, Inc. | 2 | $24.9 |
| 12 | 12 | P R C, Inc. | 3 | $24.7 |
| 13 | 18 | Aerojet General Corporation | 3 | $23.5 |
| 14 | 13 | Cortez III Service Corporation | 2 | $22.7 |
| 15 | 33 | Parsons Infrastruction & Tech. | 2 | $21.0 |
| 16 | 17 | General Sciences Corporation | 10 | $19.1 |
| 17 | 25 | Spectrum Astro, Inc. | 3 | $17.4 |
| 18 | 10 | Computer Sciences Corporation | 25 | $16.7 |
| 19 | 15 | Space Systems Loral, Inc. | 3 | $13.6 |
| 20 | 26 | Global Science & Tech., Inc. | 8 | $9.5 |
| 21 | 57 | Honeywell Technology Sols., Inc. | 17 | $9.4 |
| 22 | 30 | L B & B Associates, Inc. | 2 | $9.3 |
| 23 | 42 | Booz Allen & Hamilton, Inc. | 7 | $8.7 |
| 24 | 39 | Government Micro Resources, Inc. | 40 | $8.6 |
| 25 | 182 | R S Information Services | 2 | $8.4 |



**University Partnerships**
Goddard continued to establish partnerships with some of the nation's leading universities and colleges in an attempt to foster more meaningful and productive relationships in the areas of Earth and space science research and education.

Currently, Goddard's Earth Science Directorate is interested in establishing partnerships with a variety of institutions in the hope that the two could collaborate in proposal development and other activities. Another objective is to exchange personnel for the purposes of research and classroom instruction. Schools involved include the University of Maryland, the Massachusetts Institute of Technology, Scripps Institution of Oceanography, the University of Wisconsin, Colorado State University, University of Arizona, George Mason University, Howard University, Columbia University, Rutgers University and the University of New Hampshire.

| FY 01 | FY 00 | Institution | Number of Contracts | Millions of Dollars Obligated |
|---|---|---|---|---|
| 1 | 1 | Johns Hopkins University | 129 | $127.9 |
| 2 | 2 | Assoc. of Universities for Res. in Astronomy | 25 | $74.3 |
| 3 | 3 | University of Colorado – Boulder | 176 | $37.6 |
| 4 | 5 | California Institute Technology | 82 | $24.6 |
| 5 | 6 | University of Maryland – College Park | 143 | $23.3 |
| 6 | 13 | University of California – Berkeley | 94 | $22.7 |
| 7 | 10 | Massachusetts Institute of Technology | 88 | $21.5 |
| 8 | 12 | New Mexico State University – Las Cruces | 19 | $16.3 |
| 9 | 9 | Smithsonian Institution | 166 | $15.1 |
| 10 | 8 | University of Alaska – Fairbanks | 29 | $14.3 |
| 11 | 15 | Universities Space Research | 32 | $13.6 |
| 12 | 11 | Columbia University | 55 | $13.6 |
| 13 | 11 | University of Maryland – Baltimore County | 33 | $12.1 |
| 14 | 8 | University of Arizona | 154 | $12.0 |
| 15 | 7 | University of California – San Diego | 52 | $10.7 |
| 16 | 25 | University of Hawaii | 78 | $9.9 |
| 17 | 14 | Southwest Research Institute | 64 | $9.8 |
| 18 | 17 | Pennsylvania State University | 57 | $9.4 |
| 19 | 16 | Wheeling Jesuit College | 4 | $9.4 |
| 20 | 20 | Institute Software Research | 3 | $8.8 |
| 21 | 19 | University of New Hampshire | 55 | $8.1 |
| 22 | 24 | Stanford University | 48 | $7.8 |
| 23 | 20 | University of Washington | 72 | $7.4 |
| 24 | 21 | University of Texas – Austin | 47 | $7.2 |
| 25 | 85 | Montana State University | 10 | $7.0 |




**Top 25 Nonprofit Institutions for FY01**



# Neighborhood Relations

The events of September 11 underscored the importance of community and the need for all Americans to contribute in some way to it. Since our founding in 1959, the Goddard Space Flight Center has tried to be a good neighbor. Over the years, we have supported the local economy, and we have willingly shared our expertise, resources, and, most importantly, ourselves with the community at large. The following are snapshots of just a few of our many neighbors.

*Greenbelt Mayor Judith Davis, pictured here in front of the Greenbelt Community Center and library, is no stranger to the Goddard Space Flight Center. She and members of the Greenbelt City Council attend many of the Center's community-oriented events.*

*BELOW: Goddard salutes Lt. Paul Peterson, firefighter Danny Stallings and Capt. Charles Fowler, who risk their lives as part of their work with the Glenn Dale Volunteer Firefighter Association.*

*Part of the National Park Service, Greenbelt Park is a retreat from the pressures of life and a refuge for native plants and animals located just 2-1/2 miles from Goddard.*

*Research biologist Don Sparling, who has worked at the Patuxent Wildlife Research Center for 14 years, stands in front of one of the center's experimental wetlands.*

*Local pilot Jack Robeson is just one of many area residents who use the College Park Airport, the world's oldest continuously operated airport. This photo was taken after Robeson had installed a prop lock onto a vintage airplane. The device, which prevents the propeller from turning until it is removed, became an aviation requirement following the September 11 attacks.*

*Pictured here is Dr. Phyllis Johnson, who directs the Beltsville Agricultural Research Center. The center is home to 47 laboratories, more than 400 buildings and, of course, livestock. The center has been a Goddard neighbor for more than four decades.*

*Principal Greta Lee each year hosts more than 80,000 students, who visit the Howard B. Owens Science Center. The facility includes a Challenger Learning Center, a planetarium and a nature trail.*

*Eleanor Roosevelt High School (top) and DuVal High School (above) serve the community.*



# LEARNING AT GODDARD

*For Goddard employees, it is never too late to learn. Goddard cultivates this culture of intellectual curiosity—a hallmark of the Center since its founding more than 40 years ago—by offering a range of programs to enhance employees' job skills and opportunities for personal discovery. Seeing to the intellectual growth of its employees is only part of the equation, though. The Center also reaches out to employees' families, students and the general public in the hope of raising their level of scientific literacy.*

**Colloquia Series**
Offering opportunities to hear guest speakers is one of Goddard's more cherished traditions. Long known for its engineering and science colloquia, the Center now offers a relatively new offering—the Information Science and Technology Colloquia Series. Less technical topics also are presented under the Director's Colloquia Series, which during the fiscal year featured 10 distinguished speakers who spoke about everything from building trust in the workplace to awakening the heroes within each of us.

**Learning Center**
Goddard's Learning Center can be compared to a small university. Available to all civil servants and contractor employees at no cost, the facility offers more than 350 self-paced courses in engineering, science, computers, mathematics, supervision and management, organizational development, communications, foreign languages, health and safety and career and personal development. Courses are delivered using interactive CD-ROM, videodisk, computer-based video and audio training materials.

**The Library**
The Goddard Library celebrated its 40th birthday by paying tribute to the many innovations that have made its mission of delivering information to Goddard employees more efficient. One of its chief missions is "taking the Library to the users' desktop." The Library now offers more than 600 eJournals, 1,000 journal subscriptions and has begun digitizing selected colloquia and making them available for desktop viewing. Also available is its growing collection of electronic books. A search engine allows users to identify books by subject or by entering a keyword. Results can be sorted by date or by title.

**Goddard's Child Development Center**
Providing top-quality educational opportunities is not restricted to employees. It also extends to their children. Established in 1972, the Goddard Child Development Center, Inc. provides quality childcare for 122 children, aged 24 months through Kindergarten. Membership is open to all Goddard employees and on-site contractors.

**K-12 Educational Programs**
In fiscal 2001, the Center renewed its commitment to the development of programs and services that increase scientific literacy among elementary, middle and high school students. In all, the Center provided services to 40,000 teachers and 218,000 students from across the Northeast, the geographical area that Goddard serves. Goddard's efforts have not gone unnoticed. The Baltimore-Washington Chamber of Commerce recognized the Goddard Education Program for its outstanding

*Goddard Library*

*Goddard Child Development Center*

service to the school districts, museums and science centers in the metropolitan Baltimore and Washington, DC areas.

**Technology Enhancement**
To reach a broader audience, the Center has incorporated technology into its outreach efforts. In fiscal 2001, the Center created a distance-mentoring program for Hispanic students that featured the use of e-mail, webcasting and videoconferencing. In addition, Carolyn Shoemaker, the astronomer for whom Comet Shoemaker-Levy is named, participated in a webcast to schools in Bayonne, NJ and Pittsburgh, PA as part of career program.

**Sun-Earth Days Dawn**
Just a week after Earth Day, the Center held its first-ever celebration of the Sun to coincide with the fifth anniversary of the Agency's Solar and Heliospheric Observatory (SOHO) mission. The celebration involved more than 200,000 participants who attended events in science museums and schools from Boston to Barcelona. Participants talked with scientists, turned solar telescopes toward the Sun and explored the only star Earthlings can study up close.

*Take Our Daughters to Work Day at GSFC*

*Middle school students build water rockets to learn the principles of flight and launch technology in the Canutillo Rocket Program in El Paso, Texas.*

**Historically Black Colleges and Universities**
For historically black colleges and universities, Goddard continued its support of the MU-SPIN Program, a comprehensive educational initiative that focuses on the transfer of advanced computer networking technologies to Historically Black Colleges and Universities, Hispanic Serving Institutions, and Tribal Colleges and Universities. Through MU-SPIN, these technologies are used to support multidisciplinary research and educational programs for students from kindergarten through college, faculty, administrators, and community members. One of the program's principal goals is increasing the number of minorities who develop and submit research proposals in areas that interest NASA and other government agencies.

**Girls Just Want to Have Fun—And Learn About NASA**
Goddard expanded its observance of "Take Our Daughters to Work Day," by inviting Washington metropolitan-area girls aged 9-15 to experience science and technology at work at Goddard. The girls participated in hands-on demonstrations, toured Goddard facilities and listened to presentations about Goddard's Earth and Space Science programs. Organizers said they hoped to expose girls to women working in science and engineering, and encourage them to pursue these careers when they grew up.

**In the District of Columbia**
The Center also joined forces with the American Association for the Advancement of Science to help 20 public schools and collaborated with the city to support nine so-called transition schools, which are among the District's lowest-performing schools academically. In addition, some 30 Goddard scientists and engineers supported the Challenger Center's "Windows to the Universe Program" for all District sixth graders.

**Earth Science in Anne Arundel County**
Earth science education saw the implementation of a new curriculum in all Anne Arundel County public high schools. The course focuses on Earth as a system and has resulted in new collaborations with two other Maryland counties—Carroll and Frederick, which are interested in developing an advanced elective course in Earth systems science. A principal focus of the program is viewing Earth from space and honing students' skills in attaining and analyzing satellite data.



**Robotics Competition**
The Goddard-sponsored FIRST Robotics competition had a great year, say the event's coordinators. The contest was held for the first time at the Maryland State Fair, which attracted a half-million visitors. The primary objective of the robotics competition is for schools to work as teams to build a robot and then to work with others to perform a particular job.

**Sharing Goddard's Technological Innovations with the Community**
Goddard invited members of the scientific community, academia, industry, and other federal, state, and local government organizations to its third annual Technology Showcase. "Technology Showcase 2001: Expanding Scientific Discovery Through Innovation" gave visitors an opportunity to see more than 100 exhibits featuring some of Goddard's newest technologies and explore possible collaborations with Goddard's technology leaders. This year, the Technology Commercialization Office added a third day to coincide with Goddard's annual Open House, which gave the general public an opportunity to see Goddard's wealth of technology resources.

**Being the First**
When Beth Brown decided nearly a decade ago to pursue higher-level degrees in physics and astronomy at the University of Michigan, little did she know that she would become the Goddard Space Flight Center's first black woman astronomer.

That became her distinction in January, when she accepted a full-time job with Goddard's National Space Science Data Center (NSSDC), the world's largest repository of space science data. The center, which also happens to be NASA's most popular Internet destinations, houses archival data from the Agency's astrophysics, astronomy, solar physics, space plasma physics and lunar and planetary missions. It is Brown's job to make sure that the NSSDC maintains a flow of astrophysics data between other U.S. active archives and to scientists worldwide. She also is responsible for determining which data sets need to be moved to other media. In a sense, Brown is like a data sleuth.

Her real passion—and one that could ultimately help the Agency in its quest to entice more women and minorities to pursue technical careers in engineering and science—is her love for reaching out to students and sharing her interest in the stars. When invited, she talks with students about astronomy and related careers. She also has devoted many hours to enhancing an educational resource, the "Multi-wavelength Milky Way" Web page, which aims to present and explain how data across the electromagnetic spectrum is used by astronomers to learn about the Milky Way's shape, size and composition.

*Beth Brown*

At a meeting of the National Society of Black Physicists, for which she has served on the Executive Board, Brown came to a realization. "I'm in a unique position," she says. "I haven't been out of graduate school that long. I don't intimidate students. I guess I'm more approachable."

# PEOPLE OF GODDARD

## Goddard Standards

To achieve its goals, the Center has adopted the following standards, which all employees embrace:

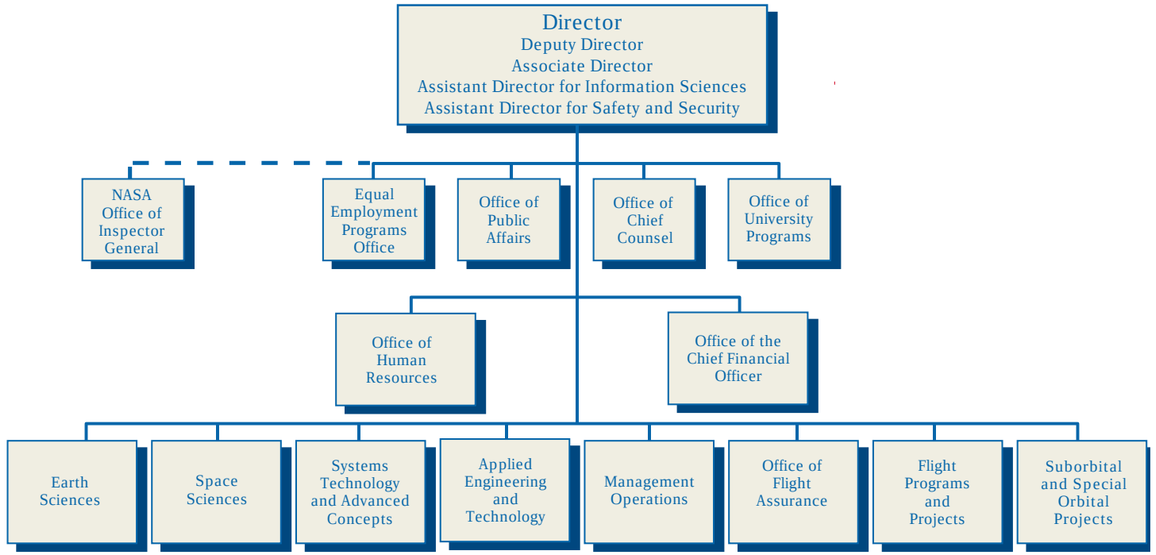
See safety as vital to the public, our astronauts and pilots and employees.

Demonstrate excellence in quality and show our customers that reliable results at an affordable cost can be expected time after time.

Meet our commitments and promises.

Sustain scientific and technological leadership in space and Earth science.

Recognize core competencies and processes that ensure the Center's competitiveness.






# GODDARD'S FUTURE

*"Our Facilities Master Plan is a 20-year vision that will give Goddard 21st century capabilities. It provides an excellent framework for making decisions about future facilities and equipment. Our vision is to make smart investments that will maintain and enhance our reputation as a world-class science and technology center, and give our employees a campus they can be proud of."*

A.V. Diaz, Center Director
Address to workforce
February 2001

Since its founding more than 40 years ago on land previously owned by the U.S. Department of Agriculture, the Goddard Space Flight Center has grown and evolved to become NASA's Center of Excellence for scientific research—a position the Center maintains by its superlative workforce, cutting-edge facilities and robust technology-development programs. Today, however, the Center finds it increasingly more difficult to perform its mission because many of its buildings are outdated and its workforce divided by geographical barriers.

Currently, Goddard's Greenbelt site is divided in two. Running north from Greenbelt Road, Soil Conservation Service Road cuts across the site, dividing it into a West campus and an East campus. The separation causes difficulties. Pedestrian safety and increased security risks to utility supply lines and services—a consideration that has become paramount since the September 11 attacks—make carrying out Goddard's scientific mission more complex and costly.

As Goddard works to more fully integrate its activities across its many sites, which include the Wallops Flight Facility, the Independent Verification and Validation Facility and others, it is more important than ever that the Center's facilities meet its needs and changing mission. Consequently, the Center initiated a master planning process to ensure that this happens.

*This artist's rendition provides a glimpse of what the Goddard campus could look like under the proposed Facilities Master Plan, which takes a 20-year look at the Center's anticipated needs and resources. If implemented, Goddard could begin making changes to its facilities in 2003.*

## Master Plan

In fiscal 2001, Goddard unveiled a preliminary draft Facilities Master Plan for the Greenbelt site that takes a 20-year look at the Center's anticipated needs and resources. If implemented, it will enable the Greenbelt facility to meet changing goals and resources, which will put it in good stead to win challenging work, attract highly skilled employees and ensure mission success.

Overall, the new plan helps Goddard achieve its goals in the following ways:

Safety. People traveling to and from the two campuses no longer are at risk.

Quality. The Center can assure that its facilities best meet the needs of its wide-ranging missions.

Efficiency. Center scientists and engineers can use the buildings and services to their fullest

Campus Unification. No longer hindered by a geographical barrier, the workforce can work more effectively.

Partners. A new zone created specifically for Goddard's partners allows the Center to work more closely with them.

Moreover, the unified campus concept concentrates Goddard's campus and its activities in already-developed areas. That means the Center can continue to preserve the wooded areas that serve as a buffer and enhance the lives of all. The master plan is, first and foremost, a commitment by Goddard to remain a vital workplace and participant in its community.

## Future Activities

In fiscal 2001, Goddard held public hearings and continues to collect public input to help refine the plan. With this input, Goddard will prepare its proposed Facilities Master Plan to external authorities for formal community review in 2002. If accepted, Goddard would begin making changes to its facilities in 2003.



# FINANCIAL STATEMENTS

FY 2003 Budget Cycle Process 345 – OMB – Baseline (8/31/01)

*Goddard by PCA by Object Level 3000 ($K)*

ENT106

| | FY 2001 | FY 2000 |
|---|---|---|
| **Total Goddard Funding** | **$2,770,747** | **$2,833,729** |
| Space Science | 863,332 | 934,473 |
| Human Exploration and Development of Space | 135,373 | 127,196 |
| Earth Science | 987,967 | 915,184 |
| Aerospace Technology | 71,489 | 65,394 |
| Safety & Mission Assurance | 15,624 | 12,602 |
| Salaries & Benefits | 306,697 | 318,373 |
| Travel | 7,984 | 7,479 |
| Other Institutional | 80,243 | 78,905 |
| Subauthorized Received | 5,849 | 5,849 |
| Reimbursables | 296,190 | 368,273 |

*Notes: HEDS also includes Biological Research; ES also includes Academic Programs and IV&V; IV&V is based on FY01 fiscal data ; Other Institutional includes Enterprise IPO, Center G&A, Compliance, Discrete Projects; Minor Revitalization, and Facility Planning; Subauthorized is based on 9/30/01 6001 Report; Reimbursable FY01 is from 9/30/01 6001 Report; FY02 form POES POP 02-1 and GOES POP 01-1*

## OVERVIEW OF THE GODDARD SPACE FLIGHT CENTER'S FINANCIAL STATEMENTS

The Fiscal Year (FY) 2001 Financial Statements have been formulated to present the financial position and results of operations of NASA's Goddard Space Flight Center (GSFC), pursuant to the requirements of the Chief Financial Officers Act of 1990 and the Government Reform Act of 1994. These statements include the Statement of Financial Position and the Statement of Operations and Changes in Net Position. The statements have been prepared from the official accounting and budgetary records of GSFC (Basic Accounting System and Fiscal System) in accordance with the form and contents prescribed by the Office of Management and Budget (OMB) Bulletin 94-01.

The statements should be read with the realization that they reflect the component of a sovereign entity; that liabilities not covered by budgetary resources cannot be liquidated without the enactment of an appropriation; and that payment of all liabilities, other than contracts, can be abrogated by the sovereign entity.

There are six direct appropriations included in GSFC's Financial Statements. The current appropriations are Human Space Flight (HSF), Science, Aeronautics and Technology (SAT), Mission Support (MS), Office of the Inspector General (OIG), and the Science, Space and Technology Education Trust Fund. Actual expenses for all appropriations, including government and non-government reimbursable activities are reflected in the Financial Statements for FY2001.

## Statement of Financial Position
*As of September 30, 2001*

| | 2001 | 2000 |
|---|---|---|
| **Assets** | | |
| Intragovernmental Assets: | (In Thousands of $) | (In Thousands of $) |
| Fund Balance with Treasury (Note 2) | $ 1,454,407 | $ 1,401,140 |
| Accounts Receivable, Net (Note 3) – Federal Claims | 12,598 | 41,220 |
| Advances and Prepayments (Note 4) | 18,119 | 5,151 |
| Governmental Assets: | | |
| Accounts Receivable, Net (Note 3) – Non-Federal Claims | $ 2,402 | 739 |
| Operating Materials & Supplies, Net (Note 5) | 169,457 | 253,838 |
| Property, Plant and Equipment, Net (Note 6) | 1,942,057 | 2,086,961 |
| **Total Assets** | **$ 3,599,040** | **$ 3,789,049** |
| **Liabilities** | | |
| **Liabilities Covered by Budgetary Resources:** | | |
| Intragovernmental Liabilities | | |
| Accounts Payable | $ 32,908 | $ 42,117 |
| Other Liabilities (Note 7) | 30,058 | 32,144 |
| Governmental Liabilities | | |
| Accounts Payable | 590,701 | 610,435 |
| Lease Liabilities (Note 8) | 0 | 141 |
| Other Liabilities (Note 7) | 19,363 | 17,831 |
| **Total Liabilities Covered by Budgetary Resources** | **$ 673,030** | **$ 702,668** |
| Liabilities Not Covered by Budgetary Resources: | | |
| Intragovernmental Liabilities | | |
| Other Liabilities (Note 7) | $ 545 | $ 2,106 |
| Governmental Liabilities | | |
| Other Liabilities (Note 7) | 36,032 | 34,115 |
| **Total Liabilities Not Covered by Budgetary Resources** | **36,577** | **36,221** |
| **Total Liabilities** | **$ 709,607** | **$ 738,889** |
| **Net Position (Note 9):** | | |
| Balances: | | |
| Unexpended Appropriation | $ 814,320 | $ 745,469 |
| Trust Fund Balance | 166 | 225 |
| Invested Capital (Note 10) | 2,111,514 | 2,340,658 |
| Cumulative Results of Operations | 10 | 29 |
| Future Funding Requirements | (36,577) | ( 36,221) |
| **Total Net Position** | **2,889,433** | **3,050,160** |
| **Total Liabilities and Net Position** | **$ 3,599,040** | **$ 3,789,049** |

*The accompanying notes are an integral part of these statements.*



## Statement of Operations and Changes in Net Position
*For the Year Ended September 30, 2001*

| | 2001 | 2000 |
|---|---|---|
| **Revenues and Financing Resources:** | (In Thousands of $) | (In Thousands of $) |
| Appropriated Capital Used | $ 2,617,845 | $ 2,544,442 |
| Revenues from Sales of Goods & Services | | |
| To the Public | 1,269 | 2,812 |
| Intragovernmental | 283,752 | 295,432 |
| Other Revenues and Financing Resources | (128) | (9,563) |
| Less: Receipts Transferred to Treasury | 128 | 9,563 |
| **Total Revenues and Financing Resources:** | **$2,902,866** | **$2,842,686** |
| **Expenses:** | | |
| Program or Operating Expenses: | | |
| Current Appropriations: | | |
| Science Aeronautics and Technology | $ 2,138,041 | $ 2,086,404 |
| Human Space Flight | 29,823 | 14,272 |
| Mission Support | 442,081 | 444,686 |
| Office of Inspector General | — | — |
| Science, Space and Technology Education Trust Fund | 150 | 190 |
| Noncurrent Appropriations: | | |
| Space Flight Control and Data Communications | — | (1,102) |
| Research and Development | — | (1,529) |
| Research and Program Management | — | — |
| Construction of Facilities | 7,769 | 1,524 |
| Special Fund Receipts, CY Expenses | — | (11) |
| Reimbursable Expenses | 285,021 | 298,244 |
| **Total Expenses:** | **$2,902,885** | **$2,842,678** |
| **Excess, (Shortage) of Revenues & Financing Sources Over Total Expenses** | **$ ($19)** | **$ 8** |
| **Changes in Net Position** | | |
| **Nonoperating Changes:** | | |
| Unexpended Appropriations | $ 68,851 | $ (19,048) |
| Trust Fund Balance | (59) | 225 |
| Invested Capital | (229,144) | (116,782) |
| Future Funding Requirements | (356) | (2,520) |
| **Total Nonoperating Changes** | **$(160,708)** | **$(138,125)** |
| **Excess, (Shortage) of Revenues & Financing Sources Over Total Expenses** | **$ (19)** | **$ 8** |
| **Net Position, Beginning Balance** | **$3,050,160** | **$3,188,277** |
| **Net Position, Ending Balance** | **$2,889,433** | **$3,050,160** |

*The accompanying notes are an integral part of these statements.*

## Notes to the Financial Statements
*For the Year Ended September 30, 2001*

### Basis of Presentation

In accordance with NASA's Chief Financial Officer (CFO) directive that installations begin the process of fulfilling the requirements legislated by the Chief Financial Officers Act of 1990, regarding the preparation of subject to audit financial statements (beginning FY 1996), these statements were formulated from the books and records of GSFC in conformity with form and content procedures specified in OMB Bulletin 94-01.

### Reporting Entity

GSFC is one of nine NASA field centers established to assist NASA in its mission to provide for aeronautical and space activities. The financial management of NASA's operations is the responsibility of Center officials at all organizational levels. Ultimately, the Regional Finance Office, Code 151, within the Office of the Center's Chief Financial Officer is responsible for synthesizing, aggregating, and reporting accounting events to NASA Headquarters Code B and the Department of Treasury (for cash transactions), in accordance with Agencywide financial management regulations. These statements refer only to the Goddard business.

The GSFC overall accounting system consists of numerous feeder systems. When combined, they provide the basic information necessary to meet internal and external financial reporting requirements in terms of funds control and accountability. Albeit, it is recognized that the current systems do not meet OMB Circular A-127 requirements for a single integrated financial system. NASA is moving to implementing a fully-integrated financial system. NASA has selected SAP Public Sector and Education, Inc. to deliver a commercial off-the-shelf accounting system as part of the intergrated financial program that will replace 10 different systems now used by NASA field centers. Currently, Goddard is scheduled for deployment in FY 2002.

The following six direct appropriations require individual treatment and are distinctly classified in GSFC combined accounting and control systems:

**(1) Human Space Flight (HSF)** — supports human space flight research and development activities for space flight, spacecraft control, and communications actions. This includes research, development, operations, services, maintenance, and construction of facilities, which encompass the repair, rehabilitation, and modification of real and personal property.

**(2) Space, Aeronautics and Technology (SAT)** — provides for the conduct and support of science, aeronautics, and technology programs. Research, development, operations, services, maintenance, and construction of facilities (repair, rehabilitation, and modification of real and personal property) also serve as by-products of this appropriation.

**(3) Mission Support (MS)** — funds safety, reliability and quality assurance activities in support of Agency programs and space communication services for NASA programs. The appropriation also provides budgetary resources for salaries, fringe benefits and related expenses, while supporting research and construction of facilities.

**(4) Construction of Facilities (C of F)** — provides budgetary resources for construction, repair, rehabilitation and modification of facilities, minor construction of new facilities and additions to existing structures, and facility planning and design. This appropriation was restructured and replaced in the FY 1995 NASA budget.

**(5) Office of the Inspector General (OIG)** — funds necessary for OIG salary, travel and related expenses required to conduct audits and investigations of Center activities.

**(6) Science, Space and Technology Education Trust Fund (TF)** — expenses of all property and services procured for the trust fund.

In addition to the direct appropriations, we receive funds from various federal and non-federal customers to perform aeronautical and space activities.

### Basis of Accounting

GSFC accounts are maintained on an accrual basis (i.e., expenses are recorded when incurred and revenue when earned). Expenses are classified in the accounts by appropriation in accordance with the Agencywide coding structure, which sets forth a uniform classification of financial activity that is used for planning, budgeting, accounting, and reporting. The expenses are further categorized in the General Ledger as operating or capitalized expenditures.

### Advances

GSFC distributes the majority of its funding used for the University Contracts and Grants Program by the method of Letter of Credit through the Health and Human Services (HHS) Payment Management System (PMS). The HHS serves as an agent for the U.S. Treasury in processing the drawdown of funds (disbursements) from a pre-established balance set up by GSFC based on contract/grant awards. The established balance for each University constitutes advance payments. A smaller number of university contract/grant recipients receive advance payments on a quarterly basis via Electronic Funds Transfer (EFT) payments through the U.S. Treasury system. In accordance with OMB Circular A-110, Quarterly financial reporting of transactions is provided by recipients on Federal Cash Transactions Reports (SF 272's). Detailed monitoring, funds control (against outstanding obligations), and accountability records are maintained. In addition, audits by the Defense Contract Audit Agency and NASA's OIG support this monitoring.

### Property, Plant, and Equipment (PP&E)

GSFC-owned Property, Plant, and Equipment (PP&E) may be held by the Center or its contractors. Under the provisions of the Federal Acquisition Regulation (FAR), contractors are responsible for control over and accountability for such property in their possession. The GSFC General Ledger is capable of separately classifying Government-held PP&E from Contractor-held PP&E.

Government regulation does not make a provision for depreciating PP&E under appropriated funding authority. However, in accordance with the User Charge Act and OMB Circular A-25, NASA is permitted to assess depreciation charges for the use of facilities and equipment, under the "full cost" concept, to non-government reimbursable customers. It should also be noted that depreciation of Agency assets is calculated and accounted for at the Agency level. In addition, automated data processing software is treated as operating cost rather than capitalized in accordance with GAO Title II guidelines.

Property, Plant and Equipment is capitalized when the unit acquisition cost is $100,000 or more; have an estimated useful life of two years or more; are not intended for sale in the ordinary course of operations; and have been acquired or constructed with the intention of being used, or being available for use by the Agency. Capitalized cost includes unit cost, transportation, installation, and handling and storage cost.

Land values are recorded at acquisition cost and cost of improvements. Buildings are also valued at acquisition cost, including the cost of capital improvements and fixed equipment required for functional use of the facility.

**Government-owned/Contractor-held** property includes GSFC real property, such as land, buildings, and structures, materials, plant equipment, agency peculiar property, special tooling, and special test equipment. Contractors are directed to report annually (on NASA Form 1018) plant equipment costing $100,000 or more and having a useful life of two years. In addition, this reporting includes capturing the other property categories mentioned above, regardless of the value (although most exceed $100,000), and is included in the Statement of Financial Position. This reporting is reviewed by Industrial Property Management Specialist (IPMS), Department of Defense (DOD) and the Deputy Chief Financial Officer (DCFO).

### Revenues and Other Financing Sources

GSFC receives the majority of its funding through multiyear appropriations. These include three-year appropriations for construction activities, two-year appropriations for operational and space flight activities, and a single year appropriation for civil service payroll and travel. In addition to appropriated funds, the Center performs services for federal and non-federal customers upon receipt of customers funding authority.

## Notes to the Statement of Financial Position
*For the Year Ended September 30, 2001*

### NOTE 2 – FUND BALANCES WITH TREASURY *(In Thousands):*

| | Obligated Available | Unobligated Available | Unobligated Restricted | Total |
|---|---|---|---|---|
| Appropriated Funds | 1,286,337 | $124,925 | $13,066 | $1,424,328 |
| Trust Fund | — | 166 | — | 166 |
| Reimbursable Advances | 29,913 | — | — | 29,913 |
| **Total Funds Balance with Treasury** | **$1,316,250** | **$125,091** | **$13,066** | **$1,454,407** |

GSFC cash receipts and disbursements are processed by the U.S. Treasury. The funds with the U.S. Treasury include appropriated funds, trust funds, and deposited funds for advances received for reimbursable services.

### NOTE 3 – ACCOUNTS RECEIVABLE NET *(In Thousands):*

| | Entity Accounts Receivable | Allowances for Losses on A/R & Interest | Net Amount Due |
|---|---|---|---|
| Intragovernmental | $12,598 | $ — | $12,598 |
| Governmental | 2,428 | (26) | 2,402 |
| **Total Accounts Receivable** | **$15,026** | **$ (26)** | **$15,000** |

Accounts Receivable consist of amounts owed to GSFC by other Federal Agencies and amounts owed by the public. NASA establishes an allowance amount for reporting purposes based on an analysis of outstanding receivable balances. Most receivables are due from other Federal Agencies for reimbursement of services. Non-federal customers provide advance payments which are placed on deposit with the U.S. Treasury until services are performed.

### NOTE 4 – ADVANCES AND PREPAYMENTS *(In Thousands):*

| | 2001 | 2000 | CHANGE |
|---|---|---|---|
| Intragovernmental | $18,119 | $5,151 | $12,968 |

The increase in intragovermental advances represents a governmentwide partner reconciliation requirement issued by The Office of Management and Budget.

### NOTE 5 – OPERATING MATERIALS AND SUPPLIES *(In Thousands):*

| | 2001 | 2000 | CHANGE |
|---|---|---|---|
| Contractor-held Materials | $163,946 | $247,462 | $(83,516) |
| Stores Stock | 5,512 | 6,376 | (864) |
| Standby Stock | — | — | — |
| **Total Operating Materials and Supplies** | **$169,458** | **$253,838** | **$(84,380)** |

### NOTE 6 – PROPERTY, PLANT, AND EQUIPMENT *(In Thousands):*

| Government-owned/Government-held | 2001 | 2000 | Change |
|---|---|---|---|
| Land | $ 4,964 | $ $5,473 | $ ($509) |
| Structures, Facilities & Leasehold Improvements | 501,602 | 492,426 | 9,176 |
| Equipment | 204,531 | 255,528 | (50,997) |
| Assets Under Capital Lease | — | 877 | (877) |
| Work-in-Process | 47,473 | 43,854 | 3,619 |
| **Total** | **$758,570** | **$798,158** | **($39,588)** |

| Government-owned/Contractor-held | 2001 | 2000 | Change |
|---|---|---|---|
| Structures, Facilities & Leasehold Improvements | $ 7,865 | $ $7,866 | $ (1) |
| Equipment | 66,744 | 30,106 | 36,638 |
| Special Tooling | 8,151 | 8,187 | (36) |
| Special Test Equipment | 81,145 | 78,166 | 2,979 |
| Agency-peculiar Property | 121,383 | 182,262 | (60,879) |
| Work-In-Process | 898,199 | 982,216 | (84,017) |
| **Total** | **$1,183,487** | **$1,288,803** | **($105,316)** |
| **Grand Total** | **$1,942,057** | **$2,086,961** | **($144,904)** |

*See Note 1 for discussion on Property, Plant, and Equipment .*

*Deletions or reductions of PP&E represents transfers of accountability to other NASA Centers. Other government agencies, returns for credit and disposal through plant clearance process.*

### NOTE 7 – OTHER LIABILITIES *(In Thousands):*

| Liabilities Covered by Budgetary Resources: | Current | Non-Current | Total |
|---|---|---|---|
| Intragovernmental Liabilities: | | | |
| Liabilities for Deposit and Suspense Funds | $ 145 | $ — | $ 145 |
| Liabilities for Reimbursable Advances | 29,913 | — | 29,913 |
| **Total** | **$30,058** | **—** | **$30,058** |
| Governmental Liabilities: | | | |
| Liabilities for Deposit and Suspense Funds | $ 1,730 | — | $ 1,730 |
| Liabilities for Statistical Reimbursable Cost | 2 | — | 2 |
| Accrued Funded Payroll | 17,631 | — | 17,631 |
| **Total** | **$19,363** | **—** | **$19,363** |
| **Total Liabilities Covered by Budgetary Resources** | **49,421** | **—** | **49,421** |

| Liabilities Not Covered by Budgetary Resources: | Current | Non-Current | Total |
|---|---|---|---|
| Intragovernmental Liabilities | | | |
| Accounts Payable for Closed Appropriations | $ — | $ 545 | $ 545 |
| Liabilities for Receipts Accounts | — | — | — |
| **Total** | **$ —** | **$ 545** | **$ 545** |
| Governmental Liabilities: | | | |
| Accounts Payable for Closed Appropriation | $ — | $ 10,962 | $ 10,962 |
| Liabilities for Receipt Accounts | — | 1 | 1 |
| Unfunded Annual Leave | 25,069 | — | 25,069 |
| **Total** | **$25,069** | **$ 10,963** | **$36,032** |
| **Total Liabilities Not Covered by Budgetary Resources** | **$25,069** | **$11,508** | **$36,577** |
| **Grand Total** | **$74,490** | **$11,508** | **$85,998** |

*Accounts payable include amounts recorded for receipt of goods or services furnished to the Center but not disbursed. "Additionally, throughout GSFC, cost is recognized and accrued based on information provided monthly by contractors" on cost and performance reports (NASA Form 533, Contractor Financial Management Report). The Defense Contract Audit Agency (DCAA) performs independent audits on reported cost to ensure reliability of estimates. Also further assurance is provided by GSFC resource analysts as a result of examining cost accruals generated from the NF 533s.*

### NOTE 8 – LEASE LIABILITIES *(In Thousands):*

There are no assets under Capital Lease for FY 2001.

### NOTE 9 – NET POSITION *(In Thousands):*

Appropriated Funds

| | |
|---|---|
| Unexpended Appropriations | |
| Undelivered | $676,329 |
| Unobligated: | |
| Available | 124,925 |
| Unavailable | 13,066 |
| Trust Fund Balance | 166 |
| Invested Capital (Note 11) | 2,111,514 |
| Cumulative Results of Operations | 10 |
| Future Funding Requirements | (36,577 ) |
| **Total Net Position** | **$2,889,433** |

### NOTE 10 – INVESTED CAPITAL *(In Thousands):*

| | |
|---|---|
| Property, Plant and Equipment | $1,942,057 |
| Operating Materials and Supplies | 169,457 |
| Less: Liability for Capitalized Leases | (141 ) |
| **Invested Capital** | **$2,111,514** |

# GODDARD'S VALUES

**Agility**

Anticipating the future, leading change, and adapting quickly are crucial to thriving in a dynamic environment.

**Balance**

An employee's work life and personal life, including health, family, community involvement, and other interests, contribute to the vitality both of the individual and of the Center.

**Creativity**

Freedom to explore new ideas stimulates discovery, fosters innovation and leads to more effective ways of doing work.

**Dedication**

Successful results require a commitment to excellence and to individual and team responsibilities.

**Integrity**

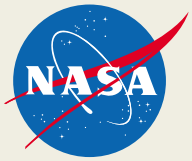
Trust, fairness, honesty and accountability for our actions are the cornerstones of personal and organizational integrity.

**Respect**

Diversity among people and their ideas is an inherent strength as we work toward fulfilling Goddard's mission.

**Teamwork**

Accomplishments result from successful teams, both internal and external to the Center, that capitalize on the strengths and contributions of every team member.



National Aeronautics and
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**Goddard Space Flight Center**

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