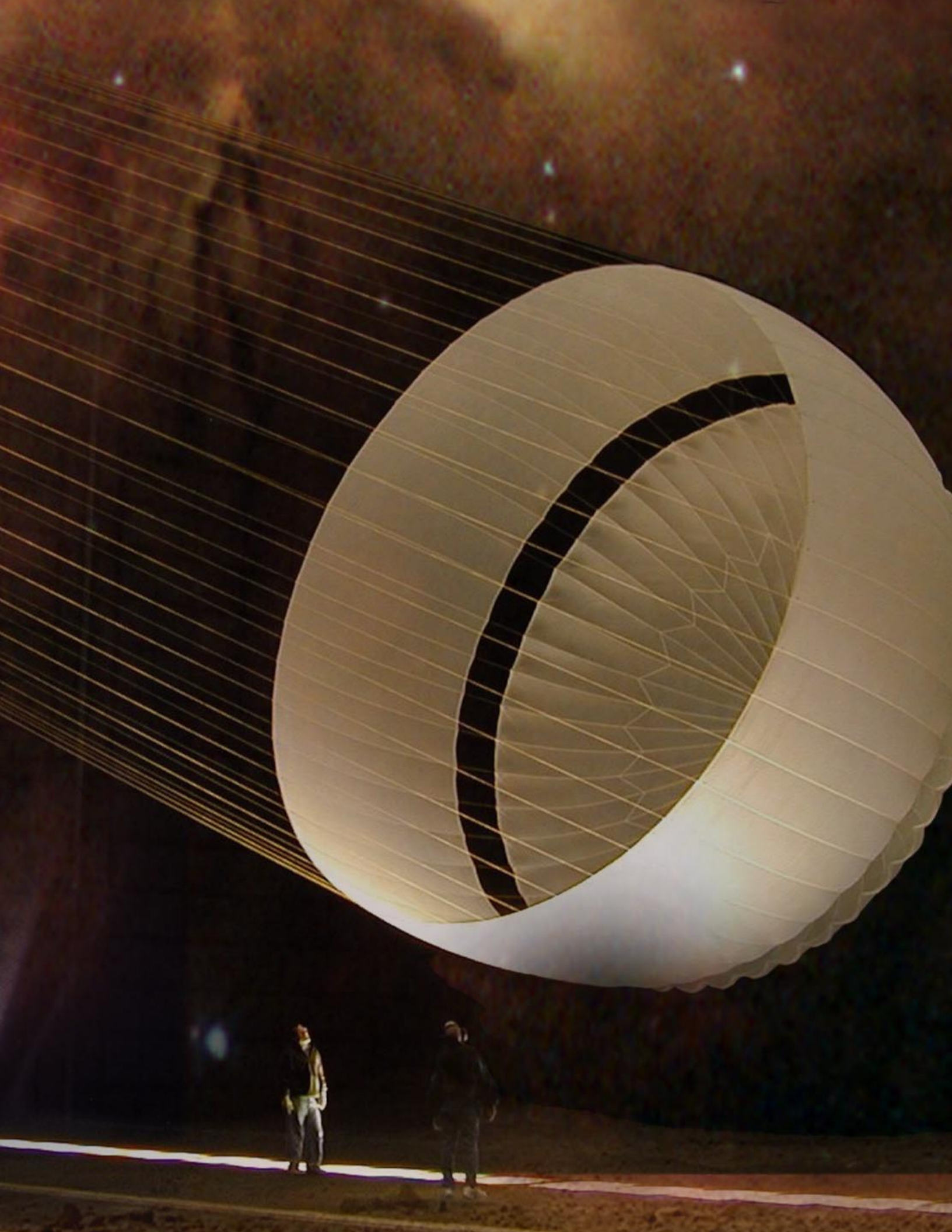


2002 **JET PROPULSION**  
LABORATORY  
ANNUAL REPORT





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Engineers used the world's largest wind tunnel, located at NASA's Ames Research Center, to test the Mars Exploration Rover landing parachute.

## **DIRECTOR'S** MESSAGE

**If the history of JPL were  
a book, we are on the  
verge of turning the page  
to one that promises to  
be one of the most excit-  
ing and busiest chapters  
in JPL's history.**



**T**he year 2002 brought advances on many fronts in our space exploration ventures. A new orbiter settled in at Mars and delivered tantalizing science results suggesting a vast store of water ice under the planet's surface, a discovery that may have profound consequences for exploring Mars. A long-lived spacecraft made its final flybys of Jupiter's moons, while another started its final approach toward Saturn and yet another flew by an asteroid on its way to a comet. A new ocean satellite began science observations, joined in Earth orbit by a pair of spacecraft measuring our home planet's gravity field, as well as JPL instruments on NASA and Japanese satellites. A major new infrared observatory and a pair of Mars rovers were readied for launch.

All told, JPL is now communicating with 14 spacecraft cast like gems across the velvet expanses of the solar system. It is a far cry from the early 1960s, when JPL engineers made prodigious efforts to get the first planetary explorers off the ground and into space — an achievement of which we were especially mindful this year, as 2002 marked the 40th anniversary of the first successful planetary mission, Mariner 2, which barely reached our closest planetary neighbor, Venus. Added to this anniversary were celebrations surrounding the 25th anniversaries of the launches of Voyagers 1 and 2, two remarkable spacecraft that are still flying and are actively probing the outer realms of the solar system. These events of the past and present provide an occasion for reflection on the remarkable era of exploration that we at the Jet Propulsion Laboratory are privileged to be a part of.

Much has changed, of course, since the launches of Mariner 2 and the twin Voyagers. JPL is no longer the only technical organization in the United States conceiving and flying robotic missions to explore the solar system. When we compete now, it is not against another superpower as it once was in the past, but, instead, these are competitions involving American institutions, all of whom seek to make their mark in space exploration. I believe this kind of competition is good for the nation, good for NASA, and good for JPL. I am proud of JPL's record in winning work through competitions. In one recent competition, JPL proposals received a third of the budget designated by NASA for propulsion technology work. In another, JPL received nearly half of the available funding in an advanced component technologies competition. In the Mars Scout competitions, all four finalists have JPL as project manager. And I am just as delighted knowing that while we have excelled in these challenges, we have at the same time successfully partnered with industry and universities, enabling the nation as a whole to continue its pioneering heritage in space exploration.

As 2002 neared its end, the Laboratory had yet another reason for celebration, as a new five-year management contract between NASA and the California Institute of Technology was signed that calls for a closer working relationship with NASA and other NASA centers as a member of the "One NASA" team. There is a strong emphasis on cost control and management, areas in which we can improve, enabling us to become more competitive. This new agreement again confirms NASA's trust and faith in Caltech and JPL, in which we should all take great pride.





**Glowing filaments and sumptuous colors bedazzle the eye in these views of the Large Magellanic Cloud and the Orion nebula. The images were taken by JPL's Wide-Field and Planetary Camera aboard the Hubble Space Telescope.**

Our work on behalf of NASA starts with the agency's new vision and mission: "To understand and protect our home planet, to explore the universe and search for life, and to inspire the next generation of explorers ...as only NASA can." From this flows JPL's mission: To explore our own and neighboring planetary systems; to search for life beyond the Earth's confines; to further our understanding of the origins and evolution of the universe and the laws that govern it; to make critical measurements to understand our home planet and help protect its environment; to enable a virtual presence throughout the solar system using the Deep Space Network and evolving it to the Interplanetary Network; to apply JPL's unique skills to address problems of national significance; and to inspire the next generation of explorers.

If the history of JPL were a book, we are on the verge of turning the page to one that promises to be one of the most exciting and busiest chapters in JPL's history. In 2003 and 2004, we will launch 11 spacecraft or major payloads. We will land two rovers on Mars; put a spacecraft in orbit around Saturn, deliver a probe to the surface of its largest moon, Titan, and map Titan's surface with imaging radar; send a spacecraft past a comet collecting samples from its tail, while another one is launched toward a comet impact; bring a capsule back to Earth with the first samples ever collected beyond the orbit of the Moon; map the skies in the ultraviolet as well as the infrared spectrum to unprecedented accuracy; and continue the mapping of ocean topography and winds on our home planet, Earth. I, for one believe this is going to be a riveting read, and I hope you will join us as the story unfolds.

Charles Elachi

# SOLAR SYSTEM EXPLORATION

**For the final encounter of its mission, Galileo flew past Amalthea, one of Jupiter's four small inner moons, none of which had ever been visited by a spacecraft.**

**J**PL's roster of robotic spacecraft exploring the solar system includes a mixture of veterans capping long and distinguished careers, and several newcomers in the early to middle stages of their space adventures.

Among the elders is the long-lived Galileo spacecraft. For the past seven years, the craft has been orbiting the solar system's largest planet, Jupiter, making more than thirty close flybys of its four major moons — Io, Europa, Ganymede and Callisto. In January, the spacecraft made a farewell visit to Io. For the final encounter of its mission, in November Galileo flew past Amalthea, one of Jupiter's four small inner moons, none of which had ever been visited by a spacecraft. Galileo determined Amalthea's density, a valuable clue to its composition. Passing closer to Jupiter than ever before, the orbiter also examined the inner region of the planet's powerful magnetic environment and studied dust particles in a faint "gossamer" ring. As the year closed, Galileo was on course on its last orbit of Jupiter. While still controllable, the orbiter is being steered into Jupiter to avoid any risk of the spacecraft hitting Europa in years to come. That precaution stems from Galileo's own discoveries of evidence for





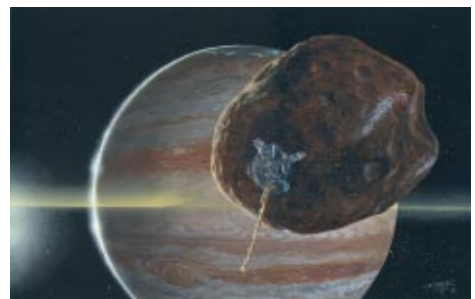
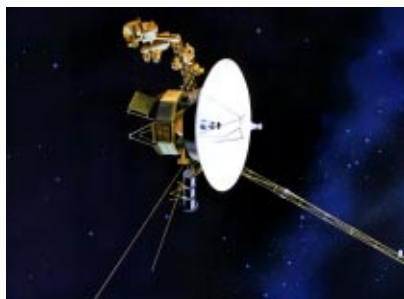
## SOLAR SYSTEM EXPLORATION

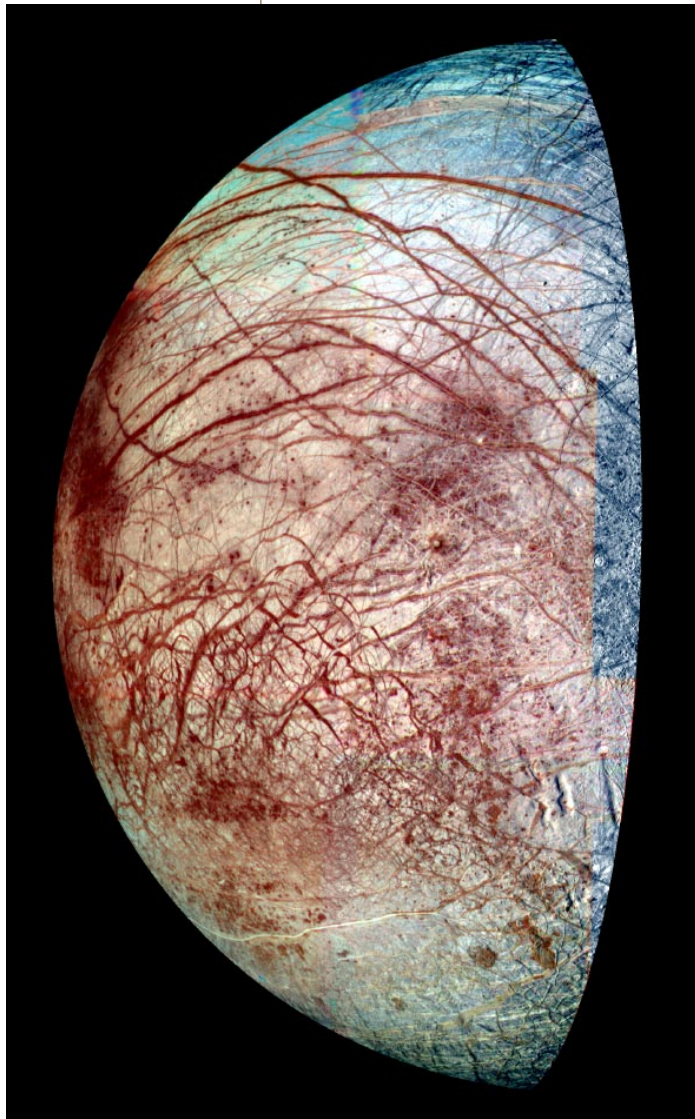
a hidden ocean under Europa's surface, heightening interest in Europa as a possible habitat for life. In September 2003, Galileo will dive into the crushing pressure of Jupiter's atmosphere.

Also among the tribal elders of robotic explorers are the twin spacecraft Voyagers 1 and 2. Launched 25 years ago this year, the mission made heralded explorations of Jupiter, Saturn, Uranus and Neptune before the two spacecraft headed out toward the edges of the solar system on the verge of interstellar space. Voyager 1, the most distant of any human-made object, surpassed 13 billion kilometers (about 8 billion miles) from the Sun in December and kept speeding away faster than 17 kilometers per second — nearly a million miles every day. Though only about 80 percent as distant as its twin, Voyager 2 is still twice as far from the Sun as the solar system's most distant planet, Pluto. Both spacecraft radio home scientific measurements virtually every day about the outer reaches of the solar wind. Researchers expect Voyager 1 to provide the first in-place sensing of true interstellar space, beyond the limit of the solar wind, before the spacecraft's nuclear power source runs too low for it to function, in about 20 years. In 2002, flight engineers made the most distant repair in history when they remotely reconfigured Voyager 1 to compensate for a balky position-sensing system.

Among the relative newcomers, the Cassini spacecraft passed the halfway point between Jupiter and Saturn in 2002 as it began the last leg of its approach toward the latter. Late in the year, the science team released its first photo of the jewel-like ringed planet where the orbiter will take up residence in July 2004. The Huygens probe, contributed by the European Space Agency, will descend through the dense atmosphere of Saturn's moon Titan in January 2005. During Cassini's cruise toward Saturn, scientists are using radio links

**Resilient Galileo soldiered on through seven years of discovery at Jupiter. An encounter (right) with the small moon Amalthea exposed the spacecraft to extremely high radiation. Voyager 1 (center) continues to seek the edge of our solar system.**





**Galileo's images and measurements of Europa — one of Jupiter's four large Galilean satellites — indicate that an ocean may lie beneath the fractured icy surface.**

spacecraft will use when it reaches the comet. The spacecraft also completed a second period of collecting samples of interstellar dust, which it also will bring back to Earth.

Among future missions, Deep Impact continued, despite technical obstacles, toward launch. The spacecraft is designed to punch a hole through the surface of a comet, providing the scientific community an opportunity to study material from the comet's interior.

between the spacecraft and Earth to search for gravitational waves rippling through the solar system.

Throughout 2002, the Genesis spacecraft gathered particles being shed by the Sun in the outward-flowing solar wind. Genesis will bring the collected material to Earth in September 2004 — NASA's first sample return since Apollo astronauts brought home Moon rocks. Analysis of the solar material will provide information about the primordial cloud of material that consolidated into clumps to form the Sun and planets billions of years ago.

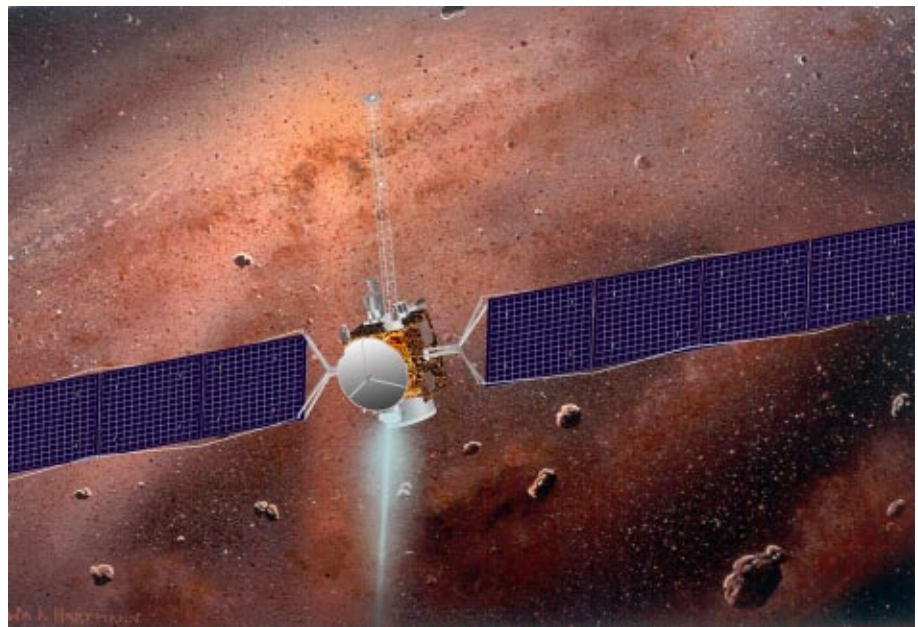
The Stardust spacecraft is more than halfway through its travels to collect dust samples as it flies by comet Wild 2 in January 2004, returning them to Earth two years later. This year, Stardust took advantage of flying near a small asteroid, named Annefrank, to run engineering tests of many procedures the

Development work intensified in the second half of 2002 on a JPL-managed mission to visit two asteroids. The Dawn spacecraft will launch in 2006 and orbit the asteroid Vesta for about a year beginning in 2010. It will then leave Vesta and travel to the solar system's largest asteroid, Ceres, which it will orbit beginning in 2014. Using the same instruments to observe these two bodies, both located in the main asteroid belt between Mars and Jupiter, Dawn will improve our understanding of how planets formed during the earliest epoch of the solar system.

A JPL microwave instrument that will fly on the European Space Agency's comet-chasing Rosetta mission passed months of testing at a facility in the Netherlands this year. In September, the assembled spacecraft was shipped to South America for launch from Kourou, French Guiana. When Rosetta orbits its target comet, scientists will use JPL's microwave instrument to examine the escape of gases from the comet nucleus.

**Previous modifications of one of the two telescopes used by the Near-Earth Asteroid Tracking program provided a larger field of view, suitable for near-Earth object detection.**





**The Dawn mission focuses on two of the first bodies formed in the solar system — the surviving protoplanets Ceres and Vesta.**

Ground-based JPL activities in 2002 continued to build the important library of knowledge about asteroids whose orbits come near Earth. The Near-Earth Asteroid Tracking program surveys the sky systematically from Hawaii and Southern California to find space rocks that could be on a collision course with Earth. This program and others have now located nearly half of the estimated total of near-Earth asteroids greater than 1 kilometer (0.6 mile) in diameter.

# MARS EXPLORATION

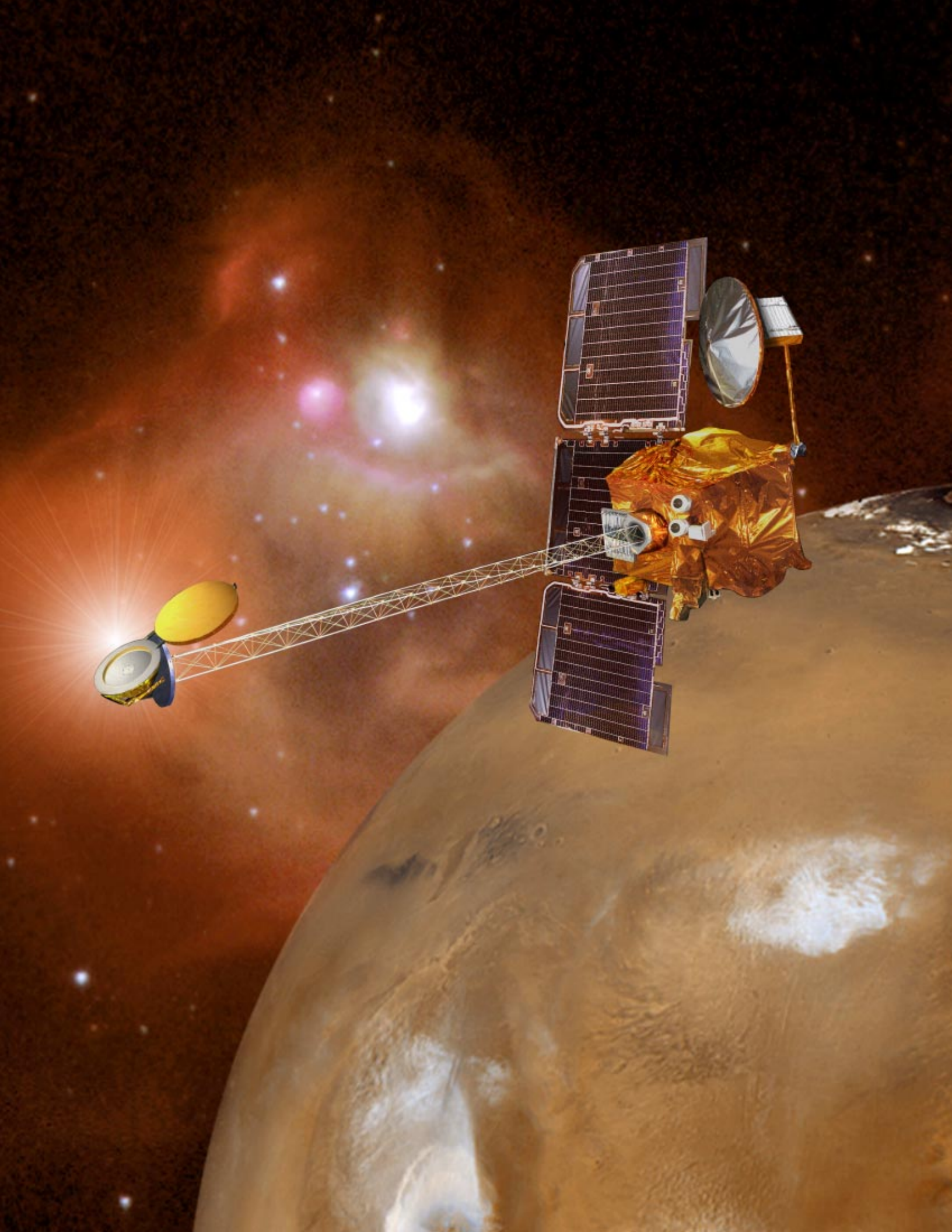
**Initial results indicate there are enormous quantities of buried water ice lying just under the surface of Mars — enough water ice to fill Lake Michigan twice over.**

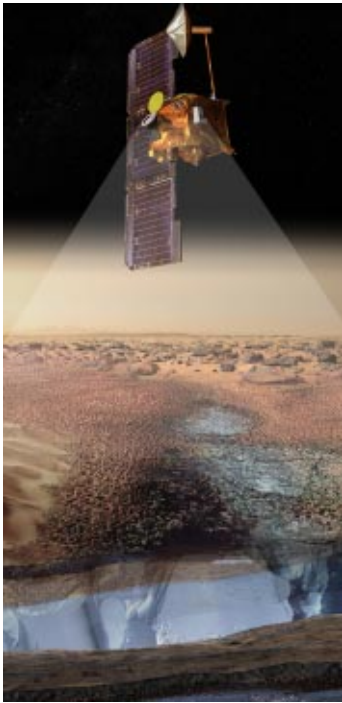
The year on Mars began with the newest arrival, a robotic orbiter, getting right down to business and delivering major science news. Back on Earth, JPL teams were busy preparing the next mission due for launch, a pair of Mars rovers.

The science news was courtesy of Mars Odyssey, which entered orbit at the red planet in October 2001. Ground controllers spent several weeks gradually reshaping the spacecraft's orbit from a looping ellipse to a tight circle, a process that was completed in January 2002. In February, Odyssey deployed its high-gain communications antenna, and a few weeks later began its science mapping mission.

Initial results indicate there are enormous quantities of buried water ice lying just under the surface of Mars — enough water ice to fill Lake Michigan twice over. This finding came from an instrument on Odyssey called a gamma ray spectrometer. Early in the science mission, the spectrometer detected considerable amounts of hydrogen in a large region surrounding the planet's south pole. Hydrogen, in turn, was viewed as a telltale sign of water ice in the upper meter (3 feet) of the soil.

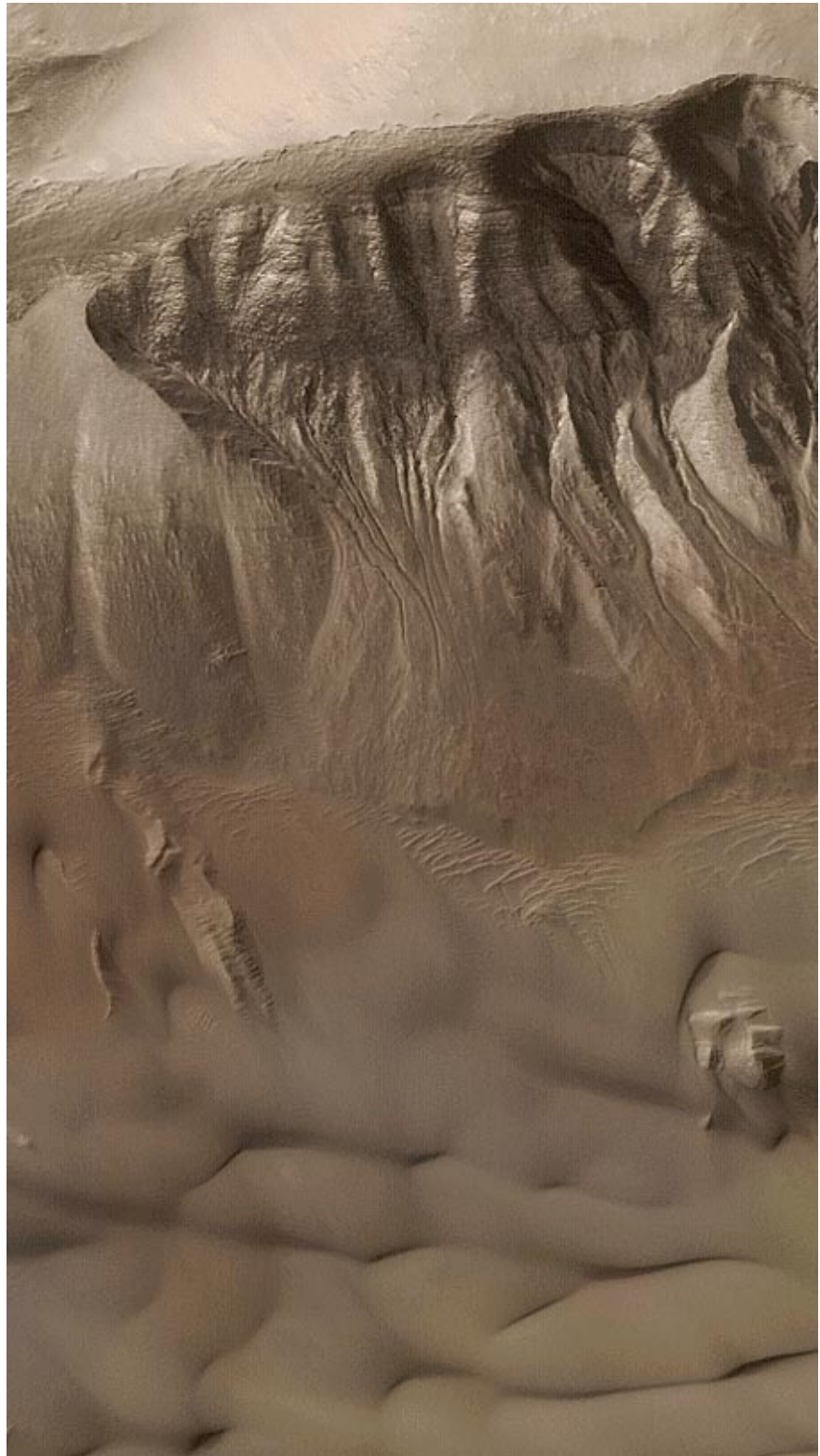
In March, Odyssey's flight controllers completed troubleshooting a science instrument designed to study Mars's radiation environment experiment that had proved to be balky during the spacecraft's passage from Earth to Mars. The instrument revealed that the daily dose of radiation experienced by astronauts on their way from Earth to Mars would be more than twice the dose endured by astronauts currently living on the International Space Station.





**This artist's rendering portrays ice-rich layers in martian soil detected by Mars Odyssey.**

**Gullies and dunes in a crater in Newton Basin were captured in sharp relief by Mars Global Surveyor. Wintertime frost dapples the crater wall.**





**Artist's concept of one  
of the Mars Exploration  
Rovers traversing a  
rocky martian field.**



The thousands of infrared images taken so far by *Odyssey* reveal that Mars experienced a series of environmental changes during active geological periods in its history. The camera team also began working on the Mars Student Imaging Project, a science education program funded by JPL and operated by the Mars Education Program at Arizona State University in Tempe. The project gives thousands of fifth- to 12th-grade students the opportunity to do real-life planetary exploration and to study planetary geology using *Odyssey*'s visible-light camera.

*Odyssey* isn't the only orbiter at Mars; it circles the planet along with Mars Global Surveyor, which reached Mars some four years before *Odyssey*, in 1997. Global Surveyor continued to shoot stunning pictures as it began the second extension of its successful mission in January 2002. By October, the spacecraft had archived 112,218 images, more than twice the number of pictures of Mars acquired by the two Viking orbiters of the 1970s. Included in that array is one of the highest-resolution images ever obtained from the red planet — a view of gullies in a crater in the Newton Basin.

Back at JPL, teams were busy preparing a pair of Mars Exploration Rovers to be launched in May–June 2003. During the summer of 2002, scientists concluded a 10-day test using a prototype rover similar to the mobile robots that will be launched to Mars. The purpose was to accustom the science team to the process of conducting field geology by remote control with a distant rover. It was a blind test in the sense that scientists were told nothing about the terrain that the rover was on apart from what they learned through the rover's science instruments. Assembly and test operations continued throughout the year on the flight hardware of the twin Mars Exploration Rovers.



# EARTH SCIENCE

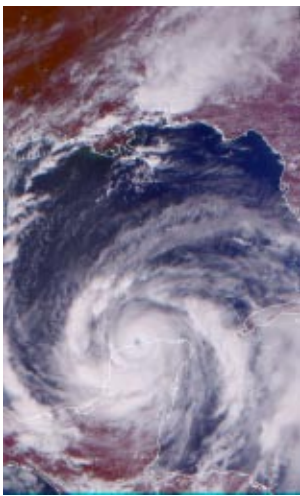
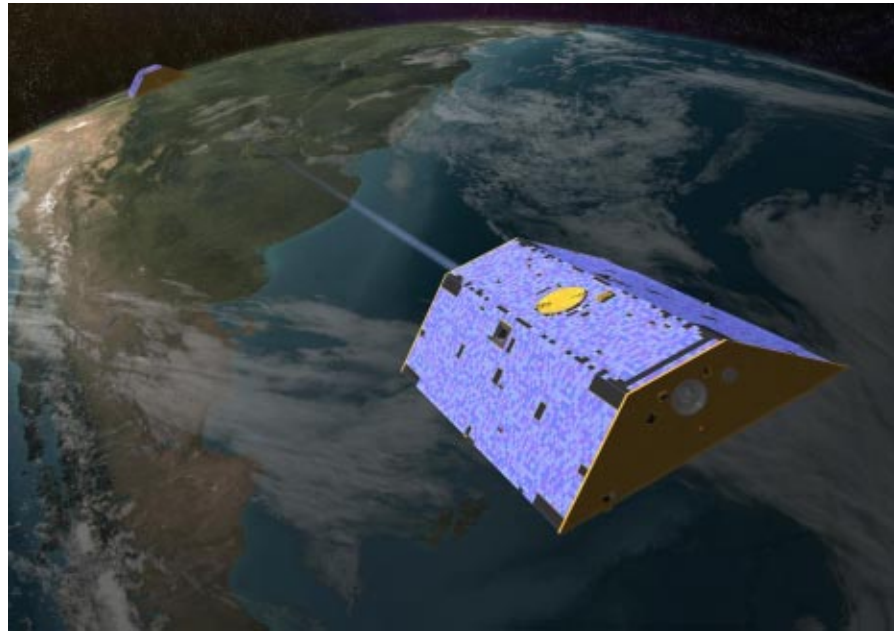
**Jason began a tandem mission with Topex/Poseidon that will enable improved detection of ocean eddies, coastal tides and currents.**

**T**he traditional alchemist's elements of air, earth, fire and water blended in 2002 as JPL Earth science missions conducted comprehensive studies of our home planet.

The fire was the glare from rockets launching several new JPL spacecraft or instruments. In March, NASA launched the Gravity Recovery and Climate Experiment, or Grace, a pair of satellites developed jointly with the German Aerospace Center using a converted Russian intercontinental missile. The mission is precisely measuring the distance between identical twin satellites flying in formation, sensing minute variations in Earth's surface mass and corresponding variations in Earth's gravitational pull, and tracking their changes over time. Grace's gravity maps will be up to 1,000 times more accurate than current maps, substantially improving the accuracy of many techniques used by oceanographers, hydrologists, glaciologists, geologists and other scientists to study phenomena that influence climate.

In May, a JPL instrument called the Atmospheric Infrared Sounder was launched aboard NASA's Aqua satellite. As it orbits, the instrument is creating a global three-dimensional map of the temperature and

The twin orbiting satellites of the Gravity Recovery and Climate Experiment detect tiny variations in Earth's uneven gravity field.



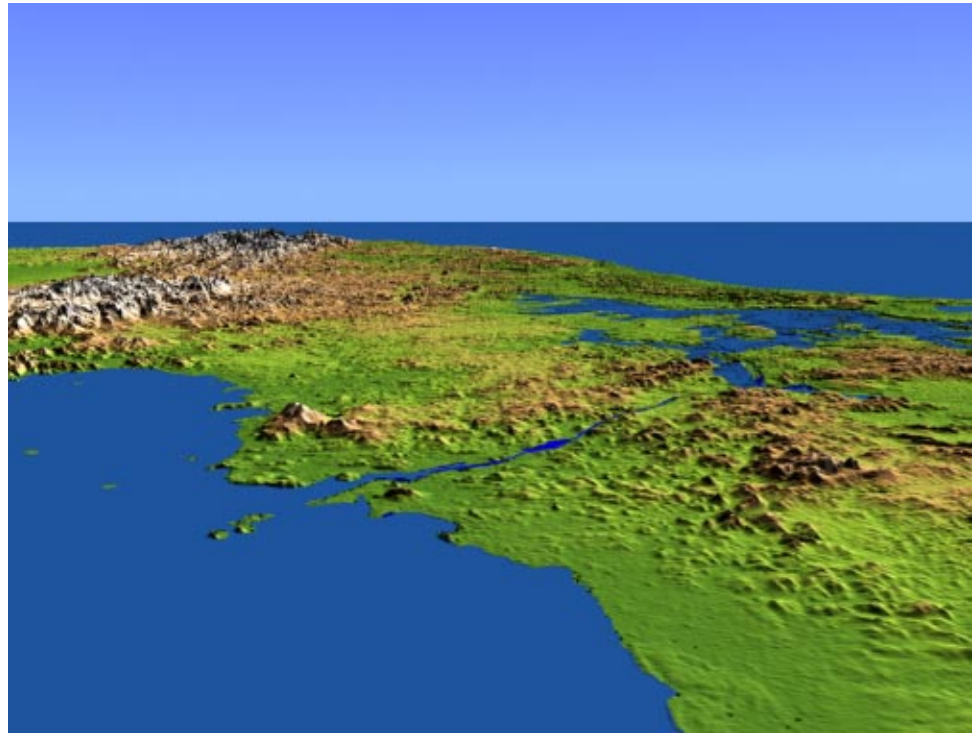
The Atmospheric Infrared Sounder “sees” at different wavelengths simultaneously. This combined visible and near-infrared image shows fine details of Hurricane Isidore’s cloud structure.

humidity of Earth’s atmosphere and providing information on clouds and greenhouse gases. Data will be used by the National Oceanic and Atmospheric Administration and its National Weather Service to improve the accuracy of their weather and climate models.

In December, JPL’s SeaWinds instrument was launched aboard Japan’s Advanced Earth Observing Satellite 2. SeaWinds is the latest in a series of instruments that bounce radar pulses off the surface of the world’s seas to calculate the speed and direction of near-surface ocean winds. Its measurements will be used to improve weather forecasting and modeling, detect and monitor severe marine storms, identify subtle changes in global climate and better understand global weather abnormalities such as El Niño and La Niña.

The recently launched scatterometer joins a nearly identical instrument on another spacecraft, QuikScat, launched in 1999. In 2002, QuikScat achieved an important milestone when weather prediction agencies in the United States and Europe began incorporating its wind speed and direction data into their operational global weather

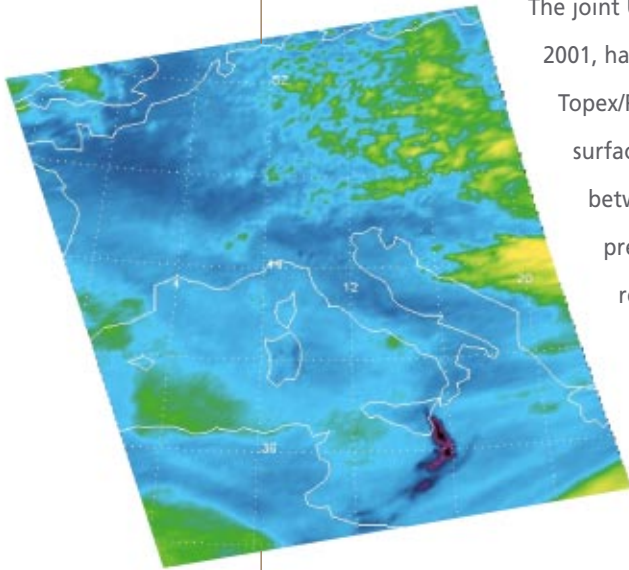
**A perspective view of the Panama Canal and the Gulf of Panama with the Caribbean Sea in the distance. The image was generated from topographic data gathered by the Shuttle Radar Topography Mission.**



**This three-dimensional perspective view of the rugged San Gabriel Mountains northeast of Los Angeles was generated from Shuttle Radar Topography Mission data. Mount San Antonio, with its brilliant white rocks, rises above the tree line.**



analysis and forecast systems. Forecasters can now predict hazardous weather events over the oceans as much as six to 12 hours earlier. The move is expected to improve global weather forecasts and ultimately save lives and property.



**Atmospheric Infrared  
Sounder data can be  
processed to track  
sulfur dioxide emitted  
by volcanoes. In this  
image, the dark smoke  
plume from erupting  
Mount Etna in Sicily is  
clearly evident.**

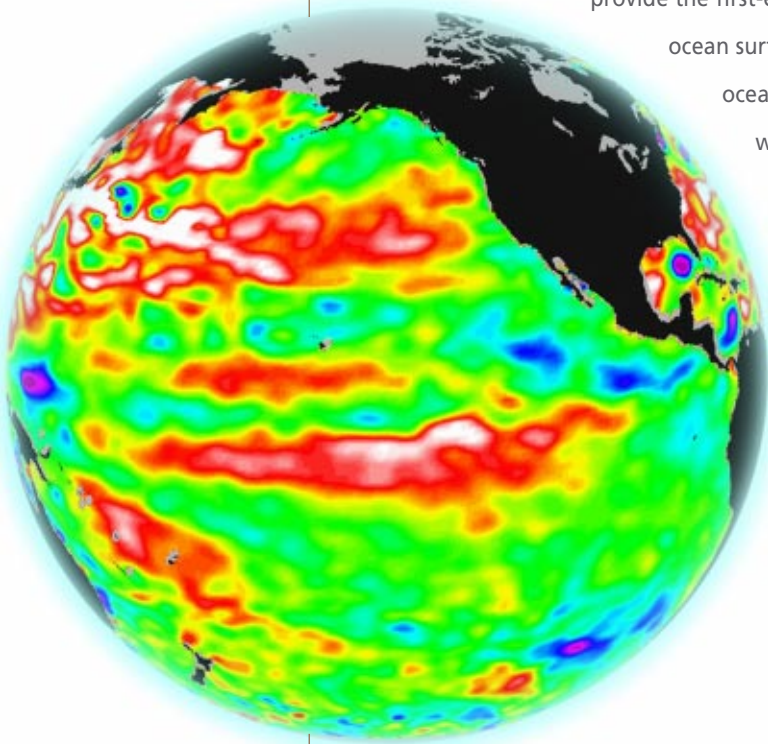
The joint U.S.–French oceanography satellite Jason, launched in 2001, had a busy year. Jason and an older U.S.–French satellite, Topex/Poseidon, measure the topography of the world’s sea surfaces to monitor ocean circulation, study interactions between oceans and the atmosphere, improve climate predictions and observe events like El Niño. In 2002, Jason reached its operational orbit, entered service, generated its first science products, underwent scientific validation and saw its routine operations handed over from the French to JPL. It also began a tandem mission with Topex/Poseidon that will enable improved detection of ocean eddies, coastal tides and currents.

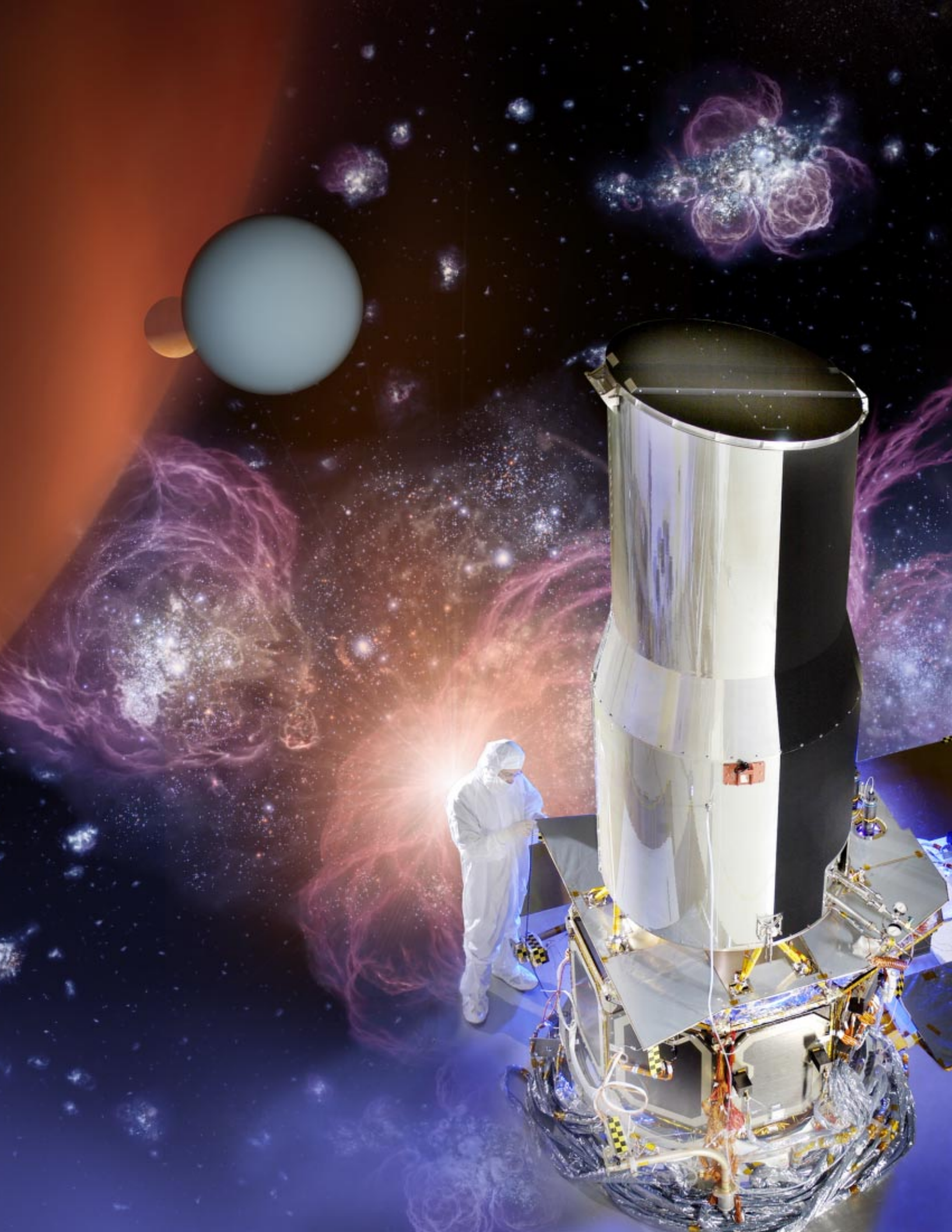
Researchers working on data from JPL’s Shuttle Radar Topography Mission, which flew in 2000 aboard space shuttle Endeavour, were busy in their quest to create the world’s best topographic maps. Data from the instrument provide the third dimension — elevation — to maps of features on Earth’s surface. In January, release of the mission’s high-resolution topographic data of the continental United States began to selected science investigators. In July, NASA reached an agreement with its mission partner, the National Imagery and Mapping Agency, on a policy to provide data from sites outside the United States to qualified researchers. By year’s end, the mission team had nearly finished processing all data from the shuttle mission — more than

**Images created from Topex/Poseidon data reveal oceanic heat storage. The large pool of warm water (red and white) in the equatorial Pacific Ocean was moving eastward in August.**

12 terabytes encompassing nearly 1 trillion measurements. For many Earth regions, the elevation maps created with these data will be ten times more precise than the best available today.

Two primary missions and an alternate selected by NASA under the agency's Earth System Science Pathfinder program will be managed by JPL. The Orbiting Carbon Observatory will yield fresh insight into our home planet's carbon cycle by providing global measurements of atmospheric carbon dioxide. This knowledge will improve projections of future carbon dioxide levels within Earth's atmosphere. The Aquarius mission, which will be developed jointly with NASA's Goddard Space Flight Center, will provide the first-ever global maps of salt concentration on the ocean surface, a key area of scientific uncertainty in the oceans' capacity to store and transport heat. Hydros, which was selected as an alternate mission, would monitor soil moisture from space.







**Throughout the year, teams made final preparations of a major new orbiting observatory, the Space Infrared Telescope Facility, planned for launch in 2003.**

## **ASTRONOMY AND PHYSICS**

**A**s the number of planets discovered around other stars surged above the 100 mark in 2002, JPL stepped up its involvement in the hunt for extrasolar planets, both in space and on the ground. In addition, JPL continued its in-depth studies of stars, galaxies, the universe and the finer points of the physics concepts that regulate the cosmos.

Throughout the year, teams made final preparations of a major new orbiting observatory, the Space Infrared Telescope Facility, planned for launch in 2003. The mission will study the early universe and hunt for planet-forming regions in dust discs around nearby stars.

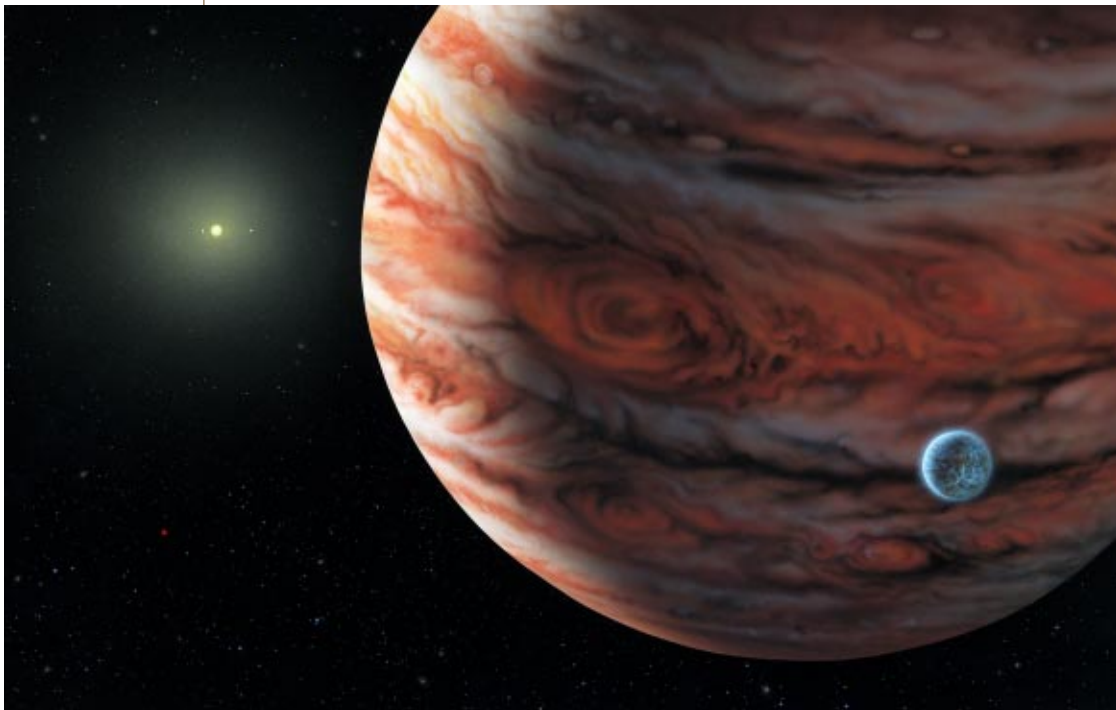
Five million astronomical images taken by the Two Micron All-Sky Survey, a project by JPL and other partners, went online in the fall. These images, many of them visually stunning, are the celestial harvest from 3-1/2 years of observations by twin infrared telescopes in Arizona and Chile. The visual feast represents the most thorough census ever made of our Milky Way galaxy and the nearby universe.

JPL's venerable Wide-Field and Planetary Camera 2, which compensated for optical problems in NASA's Hubble Space Telescope when it was installed by astronauts in 1993, wound down its mission, but scientists continued to process and release remarkable images delivered by the camera. They included views of an aging, Sun-like star with an odd resemblance to a hamburger; dense, opaque dust clouds called globules in the star-forming region IC 2944; and a bow shock around a very young star in the intense star-forming region of the nearby Orion nebula. Scientists also studied images from the camera to help verify the age of the universe.

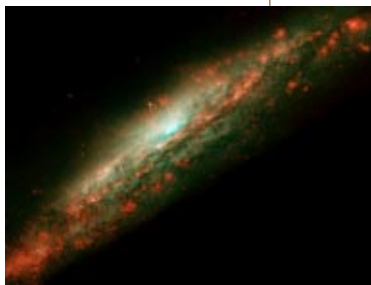
**This artist's concept shows a Jupiter-mass planet and its moon orbiting a Sun-like star. The hunt is on for Earth-like extrasolar planets.**

Another camera built by JPL, the Mid-Infrared Large-Well Imager, or Mirlin, was used at the Keck II telescope in Hawaii to produce the highest resolution mid-infrared picture ever taken of the center of the Milky Way. It revealed details about dust swirling into the black hole that lies at the heart of our galaxy.

Among future missions, plans for the Terrestrial Planet Finder mission moved ahead when two mission architecture concepts were chosen for further study and technology development. Each would use a different means to block light from a parent star in order to see much smaller, dimmer planets that might be orbiting it. One of the architectures may be chosen in 2005 or 2006; the mission is proposed for launch in the middle of the next decade.



In 2002, JPL was assigned to manage development of the Kepler mission, with the science mission led by a principal investigator at NASA's Ames Research Center. Planned for launch in 2007, Kepler will monitor the brightness of stars to find planets that cross in front of them. These "transiting" planets reduce the star's brightness, which can help astronomers detect Earth-like planets.



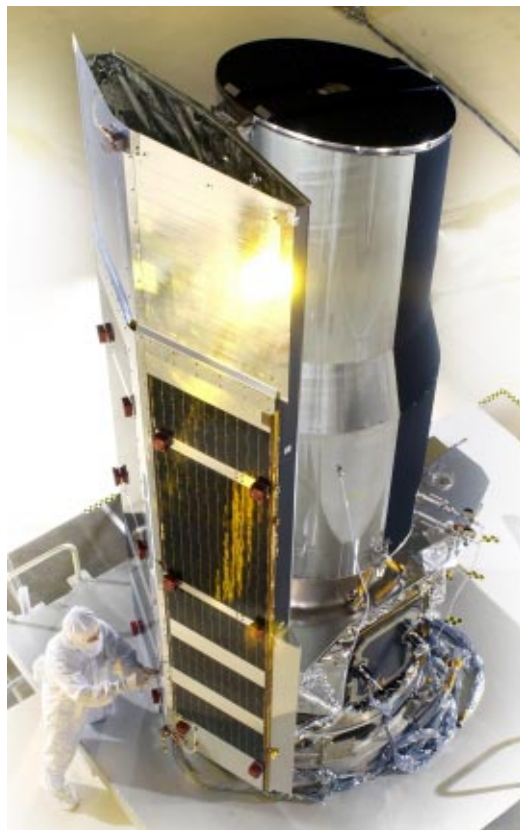
**JPL's Wide-Field and Planetary Camera aboard the Hubble Space Telescope leaves a legacy of wondrous images. Above, from left: a luminous bubble in a distant galaxy; bow shock in the Orion nebula; and a ghostly cloud around a dying star.**

**The Space Infrared Telescope Facility will study the coldest, oldest, dustiest objects in the universe. Its infrared detectors will be chilled to near absolute zero for maximum sensitivity.**

A team of scientists from JPL and Japan used a supercomputer to simulate extremely energetic jets squirted out by black holes. This work may help unlock the mysteries of these most powerful objects in the universe.

In the area of fundamental physics, breakthrough laboratory studies on waves of ultracold atoms may lead to advanced atom lasers that might eventually predict volcanic eruptions on Earth and map a probable subsurface ocean on Jupiter's moon Europa. The JPL-funded work

was performed at Rice University in Houston, Texas.



Was Einstein wrong? Research led by a JPL-funded Indiana University professor indicates that ultraprecise clocks on the International Space Station and other space missions may test Albert Einstein's special theory of relativity and could dramatically change our understanding of the universe.

# TECHNOLOGY DEVELOPMENT

**Researchers have demon-  
strated a prototype  
device that automatically  
and continuously moni-  
tors the air for the  
presence of bacterial  
spores, such as anthrax.**

**J**PL has made significant changes in its organizational structure in the past two years to align its technology development programs with flight projects and other research activities. In 2001, the non-NASA technology programs were consolidated with the Laboratory's Earth science directorate to take advantage of the many technologies with terrestrial uses that have roots in science programs designed to study our planet.

To ensure that the Laboratory's technologies and engineering capabilities contribute to the nation's different space sectors, in 2002 JPL established an office to interface with the Department of Defense, commercial entities and non-NASA civil space agencies. The new office, called National Space Technology Applications, began operations in May. The new office is focusing on joint flight demonstrations with the Department of Defense, developing alliances with commercial entities and direct technology insertion with other federal civil space agencies.

Partnering with U.S. commercial companies has provided the Laboratory with opportunities to contribute to the war on terrorism. One example is a JPL collaboration with a U.S. company specializing in environmental monitoring technologies to mutually develop a commercially available biohazard "smoke" detector. Researchers have demonstrated a prototype device that automatically and continuously monitors the air for the



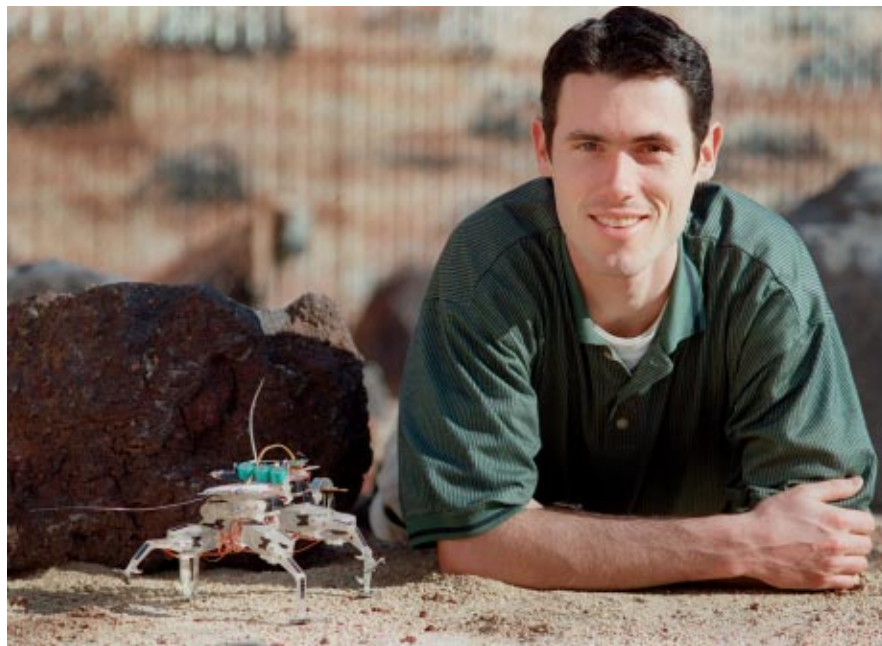
presence of bacterial spores, such as anthrax. Equally intriguing is a partnership with Sun Microsystems that resulted in JPL's mission data system software being rewritten in the Java programming language and made available to sophisticated crewed and robotic space, air and terrestrial systems.

JPL has sought relationships with Department of Defense partners in the area of air- and space-based hyperspectral imagers, space-based radars and space-based laser communications systems. Virtually invented at JPL, the first two of these three technologies are also key to Defense Department interests and will provide the Laboratory an opportunity to team with industrial and government partners developing advanced, state-of-the-art capabilities. While JPL will not compete with U.S. industrial entities, the Laboratory offers a long, successful research, development and operational history that will improve objective systems ultimately selected by the Department of Defense and its contractors.

In addition to commercial and defense collaboration, JPL is actively engaged with other federal civil agencies involved in space applications. Strong ties have been forged with the National Oceanic and Atmospheric Administration, the Department of Homeland Security, the Federal Aviation Administration and other agencies that will allow JPL technologies, concepts and capabilities to be more closely integrated with systems developed by or for those agencies. Examples include a host of technology applications for homeland security, a full-scale medium Earth orbit architecture for next-generation meteorology satellites and image processing with the National Imagery and Mapping Agency. The Laboratory has established a goal of expanding its "reimbursable" projects with non-NASA partners over the next several years from roughly \$50 million to about \$250 million per year.

The Laboratory partnered with another U.S. company on a project to provide a sharper underground view of the World Trade Center area. JPL applied its image-processing expertise to enhance underground radar images of the area around the World Trade Center, providing a clearer picture of what's beneath the surface. This work may provide the first enhanced subsurface images of the area, which will help in planning rebuilding efforts.

**A researcher and his spider-bot: equipped with cameras and feeler-like antennas, the micro robot is a prototype for future multilegged robots that could perform a variety of investigative and repair tasks.**



In a related development, a New York utility company turned to JPL to develop sensor technology to detect and quickly analyze hazardous materials of underground utility lines. The system would allow workers to take a sample and analyze it on the spot in about 30 minutes. This would give the utility company the ability to quickly determine what type of worker protection is necessary and if any personnel or equipment exposed to the hazardous material must be decontaminated. The increased speed of analysis will allow for faster cleanup and further protection of the environment.

These partnerships were enabled through JPL's Technology Affiliates Program, one of several commercial technology programs aimed at working with the private sector to use space technology to improve the quality of life. In 2002 the Technology Affiliates Program was made a part of the newly created National Space Technology Applications Office.

In the area of robotics, JPL engineering creativity spun a spider-like robot that may one day chart the terrain on other planets and explore smaller bodies, such as comets, asteroids or the Moon. Spider-bots may also help with maintenance and repairs on the International Space Station. On Earth, they might fill in for humans in investigating hazardous materials or taking soil measurements on farms.





# DEEP SPACE NETWORK

**More than 50 mission-critical events for a dozen different missions at Mars and elsewhere will rely on the Deep Space Network during the winter of 2003–2004.**

**T**he far-flung legions of JPL spacecraft communicate with Earth through the giant dishes of the Deep Space Network in California, Spain and Australia. The network, managed by JPL for NASA, handles tracking and communications not only for the Laboratory's own missions but also for solar system missions developed by other institutions and countries, as well as some spacecraft in Earth orbit. In all, the network served three dozen spacecraft ranging from NASA's Chandra X-Ray Observatory in high-Earth orbit, whose signals reach Earth in a fraction of a second, to Voyager 1 billions of miles away, whose signal takes nearly 12 hours to reach home.

Throughout 2002, the Deep Space Network placed great emphasis on preparing for an unprecedented level of demand in the winter of 2003–2004. More than fifty mission-critical events for a dozen different missions at Mars and elsewhere will rely on the network in that period. Construction continued all year on an advanced-technology dish antenna at the network's complex near Madrid, Spain. Other antennas were also being upgraded in Spain and at

## DEEP SPACE NETWORK

Goldstone, California, and Canberra, Australia. Other preparations for operational readiness during the crunch period have included training of operations teams, stocking spare parts and conducting preventive maintenance.

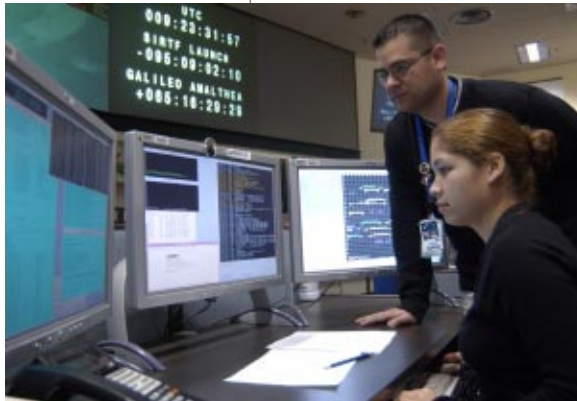
**The highly sensitive 70-meter (230-foot) parabolic dish antennas at each Deep Space Network complex pick up the faint signals from deep space missions.**



A new way of sharing global resources for deep space communications began with the launch of the European Space Agency's International Gamma-Ray Astrophysics Laboratory in October 2002. Communication with that orbiting laboratory uses a new set of international standards so that the link to the spacecraft can shift seamlessly between the European Space Agency's re-

cently built antenna at New Norcia, Australia, and antennas of the Deep Space Network. In the future, many missions and antennas will use the new standards, enabling missions of NASA, the European Space Agency and other agencies to use the combined resources of several networks.

Looking further ahead, the Deep Space Network began work on a pilot project using arrays of many small antennas to dramatically increase communication capabilities. Another promising technology, optical communications for deep space, is also in development. To make the best use of these future improvements in the "trunk lines," work is



**JPL's Deep Space Operations Center is a critical link in the Deep Space Network.**

**With three communications complexes located about 120 degrees apart in longitude, a spacecraft is in view of one of the complexes 24 hours a day. These antennas are in Australia.**



also underway to conceive of new data protocols and software applications to move toward a more Internet-like future for deep space communications.

The network's existing facilities perform double duty as communication antennas and as radio telescopes. In 2002, they helped researchers see into the past and the future. Examination of microwave emissions from discs of gas and dust swirling around the colossal black holes at the hearts of far-off galaxies not only provides insight about the black holes, it provides a new way to gauge the distance to those galaxies, an important yardstick in estimating the age of the universe. By sending out radar pulses into space to image near-Earth asteroids, astronomers can determine their orbits more precisely than they can with visual observations, offering better forecasting of where such space rocks will be centuries from now. In 2002, radar observations of asteroid 1950DA using an antenna at Goldstone, California, helped scientists conclude that this particular space rock has a slight chance — possibly one in 300, probably even lower — of being on course to hit Earth in 2880, making it a greater hazard than any other known asteroid.



USAF  
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SPACE  
DELTA

**Leaders in government  
have long realized that  
NASA space missions  
can serve as a strong  
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ence and technology,**

## ENGAGING THE PUBLIC

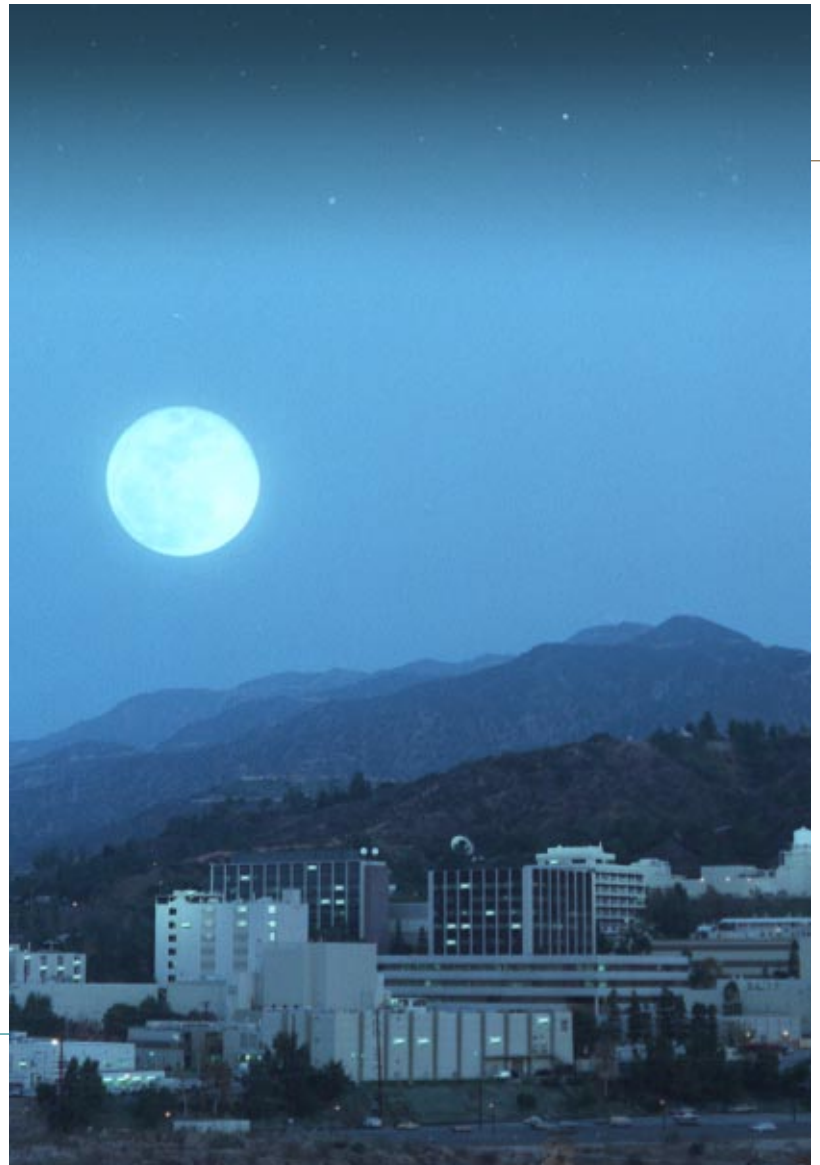
JPL's mission lies not only with its spacecraft projects and technical endeavors. Leaders in government have long realized that NASA space missions can serve as a strong inspiration to youth to pursue studies and careers in science and technology, and by doing so strengthen the nation's technical infrastructure. Many of the engineers and scientists who now work at JPL recall that their interests were shaped as youngsters by watching the televised Apollo Moon landings or other mission events.

A renewed interest in reaching young people is underway throughout NASA. Part of NASA's mission statement calls for "Inspiring the Next Generation of Explorers," and JPL is well positioned to play a leadership role in this endeavor. Four years ago, the Laboratory began consolidating its public engagement, media relations and educational activities for greater efficiency and effectiveness in reaching the public. This undertaking is now reaping benefits — for the past three years, NASA has given JPL excellent ratings for these efforts. In 2002, JPL received its highest rating ever for its public engagement activities, which range from a vigorous program of public information materials and Internet sites targeted to the general public and the news media to programs designed for K-12 and university educators.

Special achievements during the year included completing the transformation of the Laboratory's varied Web sites to a consistent graphic look, the grand opening of an updated visitors' museum, leading California-based NASA centers in working with the California State Universities on systemic education reform, supporting Arizona State University's Mars Student Imaging Project and sponsoring special events throughout the country that celebrated the 40th anniversary of the launch of the first planetary mission, Mariner 2, and the 25th anniversary of the launches of Voyager 1 and 2.

**The Laboratory intends to maintain its workforce to within a few percent of the current level and does not foresee substantial staffing growth, although needs in different skill areas will change from year to year.**

**INSTITUTIONAL**  
ACTIVITIES



One of the highlights of the year was the signing of a new contract between NASA and the California Institute of Technology for the management of JPL. Founded in the 1930s as a Caltech laboratory, JPL came under NASA jurisdiction when the space agency was created in 1958, and the NASA-Caltech contract has been renegotiated every five years since then.

The contract was signed in November 2002, almost a year in advance of the September 2003 expiration date of the current contract. Like its predecessors, the contract is for five years, but for the first time it also provides for an option to be extended an additional five years, based on performance reviews. The contract more closely aligns JPL's policies and procedures with those of NASA centers managed by government employees.

JPL's staffing level was up by about four percent from the previous year, averaging 4,851 employees and 576 on-site contractors during 2002. During the 1990s, JPL and other NASA centers took part in an agencywide initiative to reduce the size of the internal workforce and send more work to contractors. In 2000, the workforce reached its lowest level in two decades, but has risen modestly since then to adapt to workload. The Laboratory intends to maintain its workforce to within a few percent of the current level and does not foresee substantial staffing growth, although needs in different skill areas will change from year to year.

During the past year, JPL's senior management focused on questions of infrastructure: What does the Laboratory need to accomplish the finest cutting-edge work? They defined six areas of strategic focus: scientific and technical excellence; business and management excellence; strong partnerships; contribution to national security; our employees; and public engagement. Based on these strategies, JPL management developed a number of initiatives and actions to be carried out to strengthen the

## INSTITUTIONAL ACTIVITIES

**Anniversary celebrations of the Mariner 2 and Voyager 1 and 2 planetary missions brought these Laboratory directors, past and present, together at the Smithsonian Air and Space Museum. From left, William Pickering, Edward C. Stone, Lew Allen, Bruce Murray and Charles Elachi.**



Laboratory. JPL's leadership also intends to nurture technical innovation by adding resources to three programs called the Research and Technology Development Program, the Director's Research Discretionary Fund and the Centers of Excellence. Each of these gives JPL researchers the opportunity to conduct advanced research and development that lays the foundation for future space exploration.

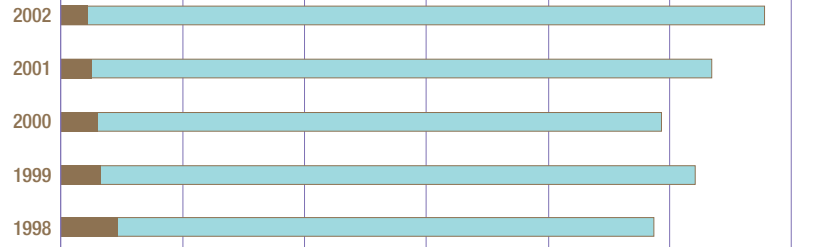
In 2002, the Laboratory's total budget was approximately \$1.446 billion, up nearly six percent from the previous year. Much of this budget was sent outside JPL in the form of procurements both regionally and nationally. Some \$285 million, for example, was spent in California. Nearly a third of JPL's contracting dollars go to small, woman-owned and/or disadvantaged businesses.



# TOTAL COSTS

Millions of Dollars 0 250 500 750 1000 1250 1500

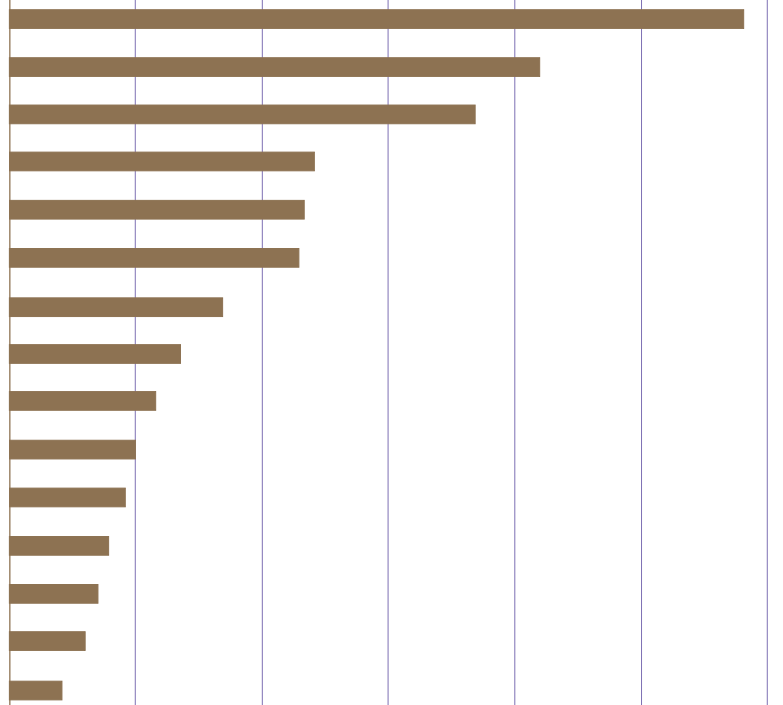
Non-NASA Research and Development  
NASA Research and Development



# FISCAL 2002 COSTS

Millions of Dollars 0 50 100 150 200 250 300

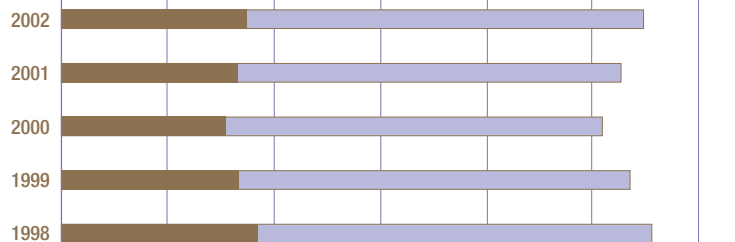
- Mars Exploration Rover Project
- Earth Science and Technology
- Interplanetary Network and Information Systems
- Planetary Flight Projects
- Astronomy and Physics
- SIRTF Project
- Solar System Exploration Programs
- Deep Impact Project
- Cassini Project
- Mars Exploration Program Office
- Other R & D
- Europa Project
- Space Interferometry Mission Project
- Cloudsat Project
- Construction of Facilities



# TOTAL PERSONNEL

Millions of Dollars 0 1000 2000 3000 4000 5000 6000

Direct Support  
Project Direct



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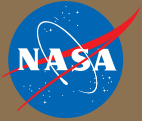
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