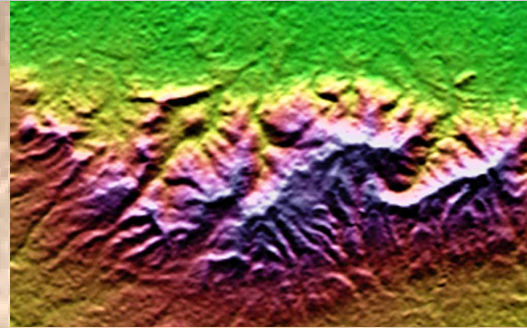


Y E A R I N R E V I E W

2001

J E T P R O P U L S I O N L A B O R A T O R Y





# 01

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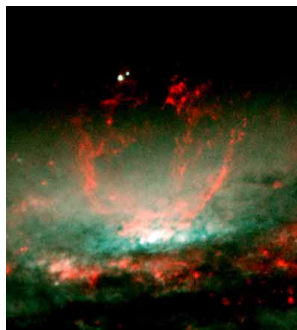
## DIRECTOR'S MESSAGE

For many years before the clock counted down to midnight and the arrival of the year 2000, the world had anticipated 2001 as a special time and a new era. Now we know that 2001 will be a year none of us will ever forget. We began a new year, a new century, and a new millennium. Yet after September 11, the world in many ways seems profoundly changed. On that day we witnessed both the worst and best in human nature.

Space exploration, I believe, is one pursuit that points towards the best instincts in our nature. And certainly the pioneering spirit, so much a part of the American character, is a value deeply embedded into all the work we undertake at JPL. We are privileged that the nation has entrusted us with exploring space on its behalf. And we are fortunate to find ourselves part of two of the world's most accomplished institutions – NASA and the California Institute of Technology.

Looking back over the past four decades, JPL has carried out an initial reconnaissance of nearly all of the solar system's planets. Today we have more than a dozen missions flying, and many more in various

The 21st century is upon us. So is a tremendous era of space exploration.



**A** glowing red bubble rises from a blue-green galactic storm in this image taken by the Wide-Field and Planetary Camera 2. New stars are being forged in this hot, swirling caldron.

stages of development. Our challenge now is to create missions that help us understand these places more deeply. And in addition to exploring and understanding our solar system, we want to discover neighboring solar systems and explore them as well.

In the next twenty years, we want to answer fundamental questions that resonate with people from all walks of life. How did the universe begin? How has it evolved? What will be its fate? How did life begin? And, are we alone in the universe? Answering these questions involves not only the expansion of our physical frontier, but also our intellectual frontier.

Our role in finding answers to these deep questions requires us to explore and understand the biological, physical, and chemical evolution of our solar system and neighboring solar systems. Expanding into these physical and intellectual frontiers means we will be probing and exploring thousands of stars in our neighborhood, eventually detecting and imaging other blue dots out there that are similar to our own planet. We want to do all these things, first of all, because the questions are simply irresistible. But we also want to find these answers so that we can apply that knowledge to understand the evolution and dynamics of our own planet – to become better stewards of our home for today and for the generations to come.

The 21st century is upon us. So is a tremendous era of space exploration. There were many events in 2001 to celebrate, as you'll see

We intend to be bold,  
as explorers must be.  
And we will insist, as  
we always have, on  
excellence in all our  
endeavors.

in the pages that follow. But let me here point out one: the arrival of the Mars Odyssey orbiter, which joins the Mars Global Surveyor orbiter in providing continuous coverage of the red planet. This is a major step in establishing a permanent robotic presence at Mars.

It is a great honor to have been chosen to lead JPL, especially at this time. The Laboratory has been a central part of my life throughout my career – and even before, in fact, since the time when, as a ten-year-old in 1958, I read of a satellite called Explorer 1 in a newspaper in my hometown in Lebanon and was inspired to pursue space exploration. I am confident that together we will make history just as our predecessors have.

Ahead of us will be both rewarding and challenging moments; that's the nature of being pioneers and explorers. We intend to be bold, as explorers must be. And we will insist, as we always have, on excellence in all our endeavors. I invite you to travel along with us on this journey as we build the cosmic spacecraft and sextants that point the way to new understanding about the universe and ourselves.

A handwritten signature in blue ink, consisting of a series of fluid, overlapping loops and strokes, characteristic of a cursive signature.

Charles Elachi



**L**ike the film and book of that name, 2001 was marked by the outset of great space ventures for JPL. Though the year may not have been ushered in by the solemn tones of “Thus Spake Zarathustra,” the Laboratory did launch a Mars orbiter paying homage to the fictional space story — 2001 Mars Odyssey. It joined two other JPL missions that were lofted into space during the year, one a craft to collect particles of the Sun and return them to Earth, the other the latest in a series of ocean-observing satellites.





**All three of the newly launched missions got immediately to work.**

**Their launches put the Laboratory in charge of a dozen currently operating spacecraft exploring the solar system and monitoring our home planet from space.**

**Space was not the only environment marked by change for JPL. On the ground, a new director and deputy director were selected and began shaping the course of the Laboratory.**

As New Year revelers rang in 2001, the Cassini and Galileo spacecraft were double-teaming Jupiter after Cassini flew past the solar system's largest planet in the closing days of December 2000.

## S O L A R S Y S T E M E X P L O R A T I O N

Seventeen days after its closest pass by Jupiter, Cassini looked back at the colorful giant planet. Jupiter's volcanic moon Io glows like a tiny jewel at left in the image.

Galileo has been orbiting Jupiter since 1995, while Cassini's observations of the planet continued for three months into 2001 following its flyby. Never before had two spacecraft examined one of the giant gaseous outer planets from two different nearby positions at the same time. The dual studies returned new information about volcanoes on the moon Io, dynamics of the magnetic environment surrounding Jupiter and other features.

The long-lived Galileo, meanwhile, had a busy year with more flybys of Jupiter's major moons. In May, Galileo flew closer than ever before to Callisto, where images showed a spiky landscape of eroding, icy spires. Galileo then flew near the north pole of the volcanic moon Io in August and near Io's south pole in October. In the north, it found a plume rising about 500 kilometers (310 miles) above a previously unknown volcano. An onboard instrument caught sulfur dioxide particles to analyze from the plume. The spacecraft's passes near Io's poles also provided important magnetometer readings indicating that Io generates little or no magnetic field of its own. By the end of the year, operating under its third mission extension, the durable spacecraft finally began to run out of propellant. After Galileo's final Io flyby in January 2002 and a pass near the small inner moon Amalthea in November 2002, plans call for the spacecraft to plunge into the crushing pressure of Jupiter's atmosphere in September 2003.

Cassini's flyby of Jupiter gave that spacecraft the last gravity assist it needed to reach its ultimate destination, Saturn, in July 2004. Cassini sent home





### Chasing a blazing comet:

Deep Space 1 performed a successful close flyby of speeding comet Borrelly, capturing the best images ever of a comet nucleus.

(Artist's concept)



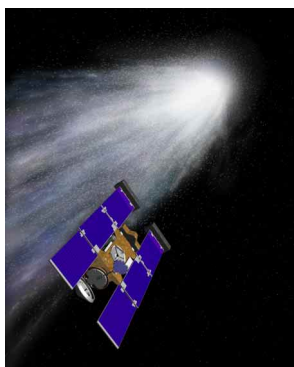
This image of the icy, dusty nucleus of comet Borrelly was taken by Deep Space 1 just 160 seconds before the spacecraft's closest approach. The nucleus is 8 kilometers (5 miles) in length.

color movies of Jupiter's cloud movements and discoveries about dust, plasma and radiation belts near the planet. Engineers devised ways this year to work around a problem discovered in the communications link between Cassini and its European-built descent probe, Huygens, which will be dropped to the surface of Saturn's moon Titan. The workaround changes the timing of Huygens' scheduled descent to January 2005. Scientists began an experiment in late 2001 to use radio links between Cassini and Earth to search for gravitational waves rippling through the solar system.

Deep Space 1 achieved one of the year's greatest successes when it pulled off a high-risk flyby of a comet in September. The spacecraft had already completed its prime mission of flight-testing advanced technologies, including an ion engine, as part of NASA's New Millennium program, so the comet encounter was like an extra-inning home run. As Deep Space 1 flew within 2,200 kilometers (1,400 miles) of the rocky, icy nucleus of comet Borrelly, it took the best pictures ever of the nucleus of a comet. It also measured the types of gases and infrared waves around the comet, and how gases interacted with the solar wind – the flows of charged particles streaming outward from the Sun.

The JPL-teamed Genesis spacecraft was launched in August on a mission to collect particles of the solar wind and return them to Earth in 2004. In November, Genesis reached its destination – a spot in space called the Lagrange 1 point, where the gravities of Earth and the Sun are balanced. The spacecraft will orbit Lagrange 1 for two years before its sample collectors are re-stowed and returned to Earth for a mid-air recovery over

The Genesis spacecraft was launched from Cape Canaveral Air Force Station on its mission to capture samples of the solar wind and return them to Earth in 2004.



**S**tardust is on its way to collect samples from comet Wild 2 in 2004 and return cometary and interstellar dust samples to Earth in 2006.  
(Artist's concept)

the Utah desert. Genesis was developed under NASA's Discovery program of low-cost solar system exploration missions teaming centers like JPL with universities and industry.

Another JPL-managed Discovery spacecraft, Stardust, flew by Earth in January, clearing a slight fog on its lens in time to snap a photo of the home planet as it sped past. Its next close brush may be the asteroid Annefrank in late 2002, when the spacecraft's software practices for Stardust's cometary dust collection near comet Wild 2 in 2004.

Among the elder Brahmins of JPL missions, Voyagers 1 and 2 continued to cruise beyond the realm of the solar system's known planets, heading toward the depths of interstellar space. Early in 2001, Voyager 1 detected a passing solar blast wave. Late in the year, it listened for radio emissions that would be set off when that blast reached the heliopause, the boundary of the solar system where the solar wind yields to interstellar wind. The timing of the emissions would provide a clue about how much farther Voyager 1, the most-distant spacecraft from Earth, has to travel before reaching the heliopause.

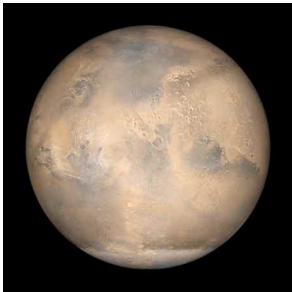
The European-American Ulysses mission, meanwhile, completed a pass over the Sun's south pole in January. It then began a final pass over the Sun's north pole in early September.

Back home on Earth, a new camera system was installed to give the Near Earth Asteroid Tracking program a wider, deeper view of the sky, enabling it to detect tens of times more asteroids and comets.



The year 2001 saw the  
Laboratory send a  
new orbiter to Mars,  
making the first time in  
more than two  
decades that two  
operating spacecraft  
orbited the red planet  
at the same time.

## M A R S E X P L O R A T I O N



In June 2001, Mars and Earth were the closest since 1988. This detailed global view is a simulated Earth-based view of the red planet composed of Mars Global Surveyor images.

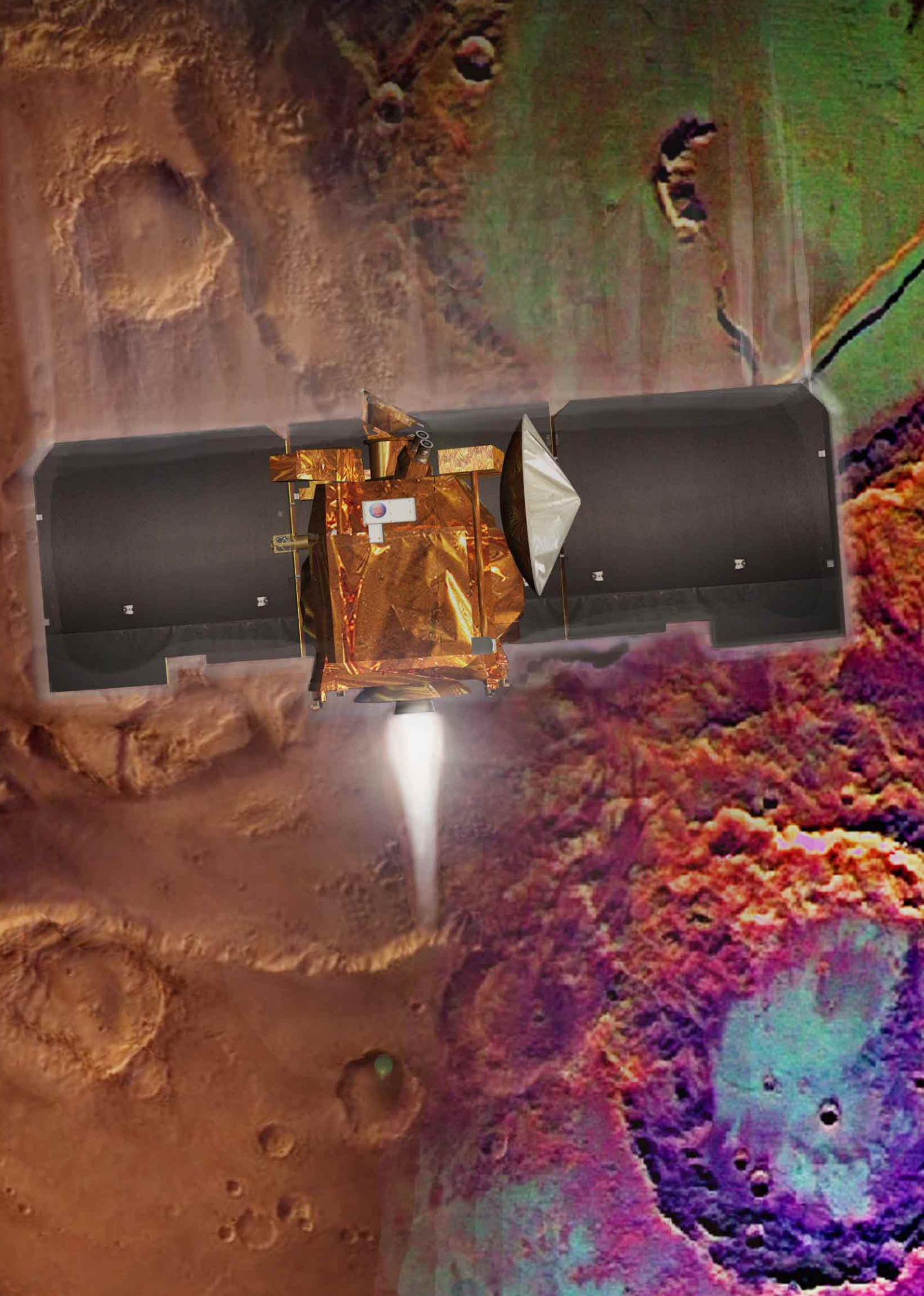
**M**ars Odyssey aerobraked into circular orbit in a series of difficult, delicate maneuvers controlled from Earth.

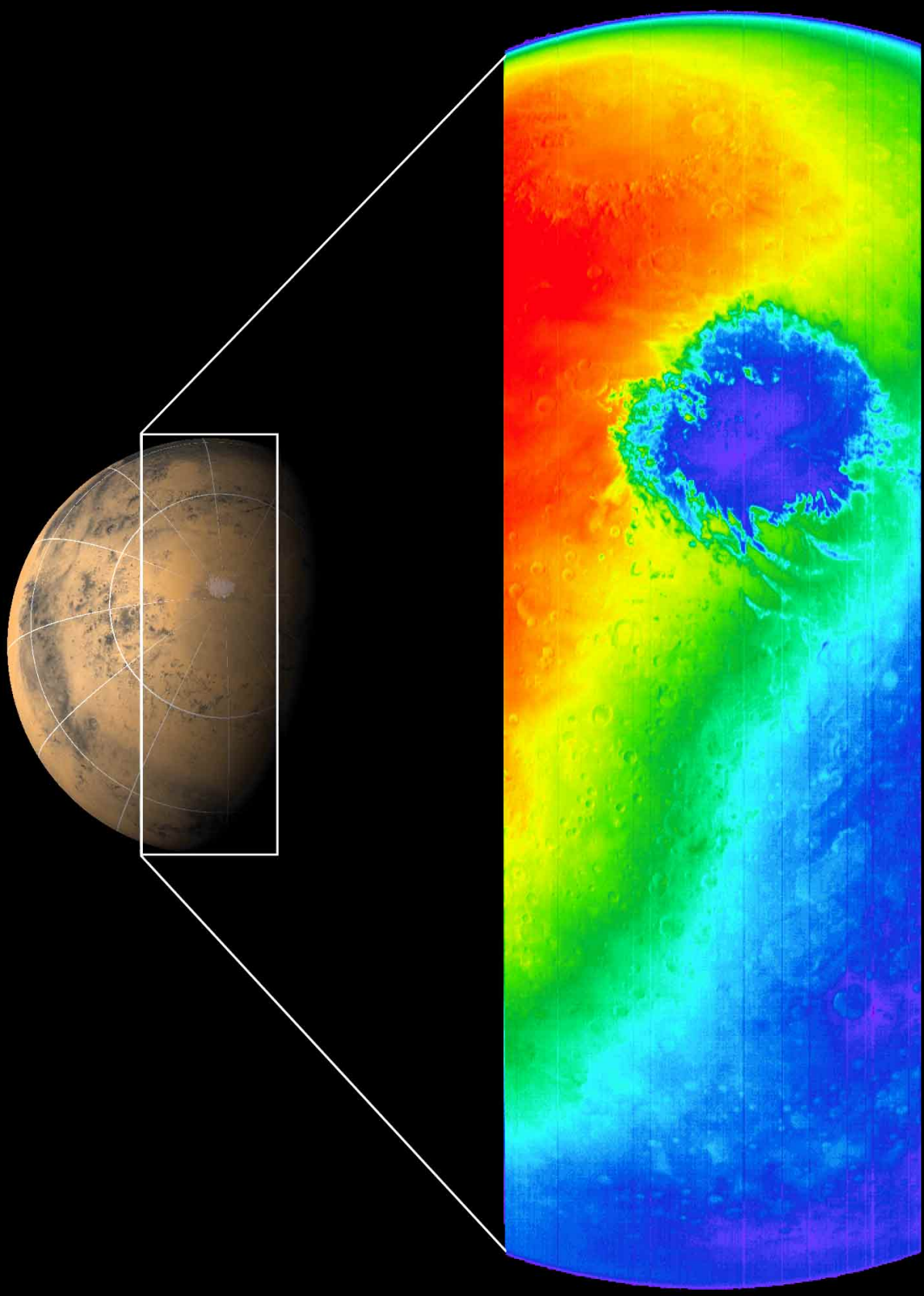
(Artist's concept; false color)

Named for the "2001" novel and film, the 2001 Mars Odyssey spacecraft was launched from Cape Canaveral, Florida, in April. Twelve days after launch, the imaging system took visible and infrared pictures of Earth and the Moon. In October, Odyssey fired its main engine for the first and only time, and was captured into orbit around Mars. Navigators were aiming for a point 300 kilometers (186.5 miles) above the planet, and hit that point within 1 kilometer (6/10 of a mile). A week after arrival, Odyssey took its first picture of Mars, a thermal infrared image of the south pole. At year's end, the spacecraft was completing three months of braking through the fringes of the planet's upper atmosphere to lower and circularize its orbit before the main science mission to study the minerals and elements that make up Mars begins in February 2002.

Odyssey joined Mars Global Surveyor, an orbiter that had collected more information about the red planet than all previous missions combined by the time it completed its primary science mission in January 2001. In an extended mission, the spacecraft concentrated on taking high-resolution images of possible landing sites for future rover missions. In June, Global Surveyor began tracking one of the largest Martian dust storms ever seen. The spacecraft's thermal emission spectrometer saw a storm begin in the southern hemisphere and observed it as the dust encircled the planet within weeks.

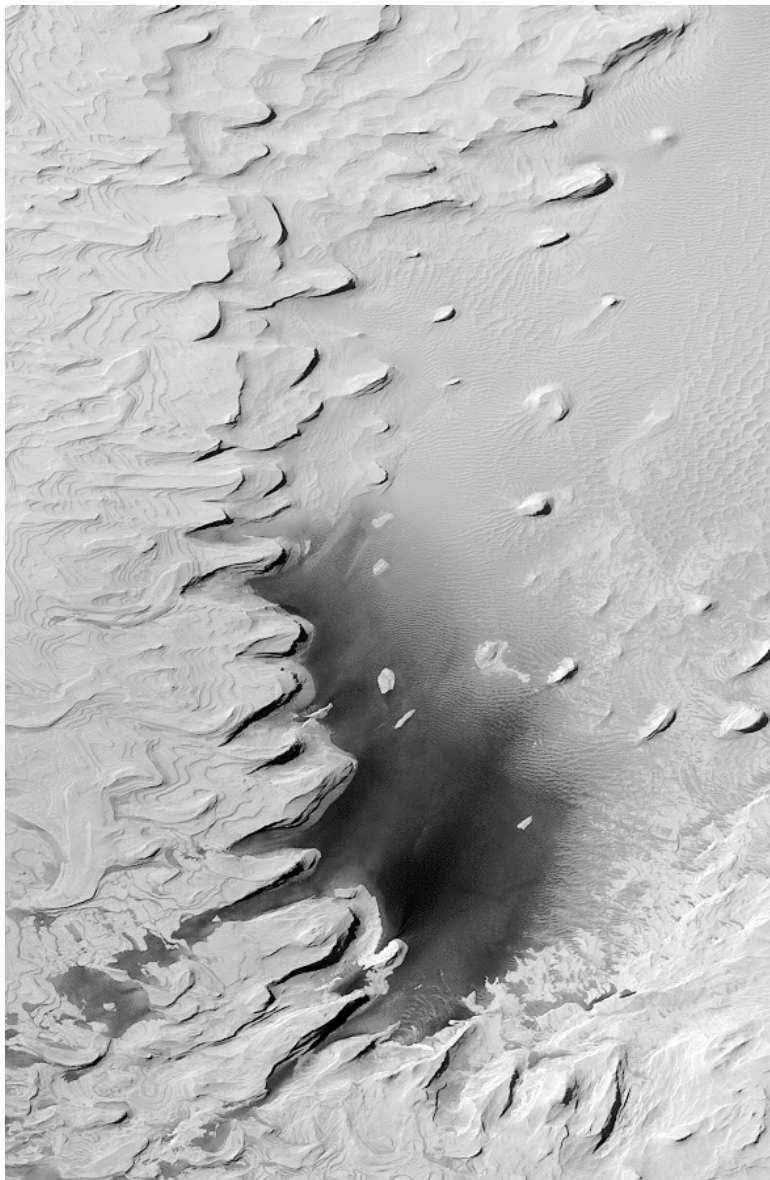




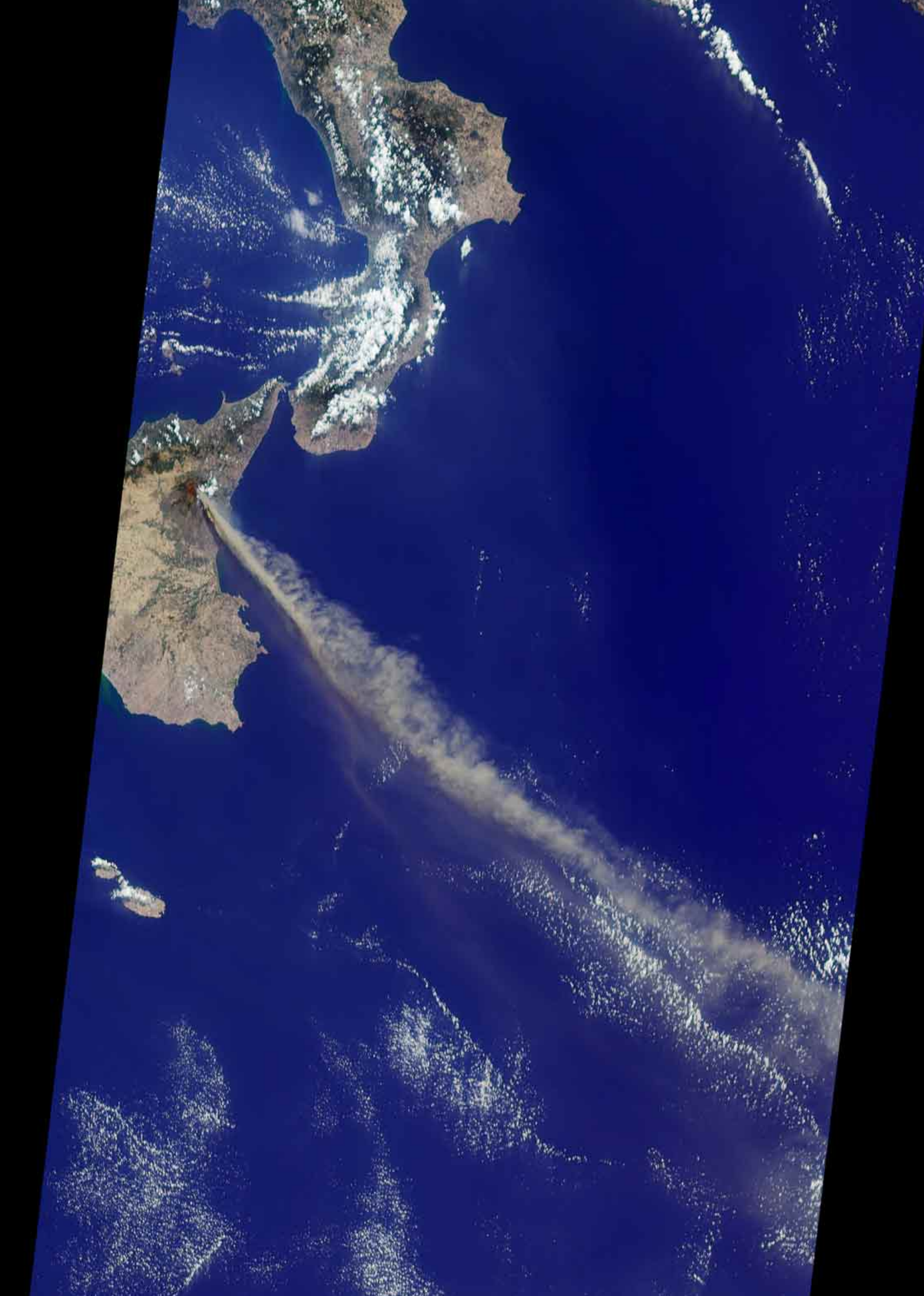


**M**ars Odyssey acquired this thermal infrared image of the Martian south pole on the spacecraft's ninth orbit. The blue areas are coldest; the circular feature is the carbon dioxide ice cap.

Engineers and scientists were also busy developing spacecraft for the next Mars launch opportunities in 2003 and 2005. The '03 Mars Exploration Rover project advanced from a preliminary design to a detailed design of the spacecraft and mission. Scientific interest and safety criteria were used to narrow down potential landing sites to four top choices – Hematite, Melas Chasma, Athabasca Vallis and Gusev Crater – from which the final two landing sites will be selected. JPL also announced selection of the contractor to design and build its Mars Reconnaissance Orbiter, a spacecraft scheduled for launch in 2005 to return the highest-resolution images yet of the planet.

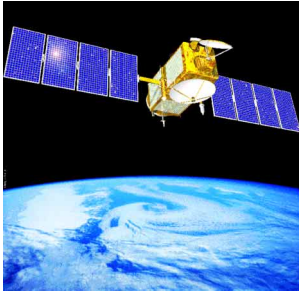


**S**culpted layered outcrops in Schiaparelli Crater were imaged by Mars Global Surveyor. The ancient rock sediments have been eroded by wind. Dark drifts of sand are seen in the lower center of the image.



Earth scientists were busy in 2001 on a variety of fronts, working with data from JPL satellites and space instruments as well as with research projects on the ground.

## EARTH SCIENCES



An illustration of Jason 1.

(Left) An eruption of Mt. Etna released two types of plumes as seen by JPL's Multi-angle Imaging SpectroRadiometer. The brown plume is volcanic ash; the smaller bluish-white plume contains water and sulfuric acid.

The venerable ocean-observing satellite Topex/Poseidon, a joint project of NASA and France's space agency, was joined in orbit by a follow-on mission called Jason 1. Whereas Topex/Poseidon featured American and French instruments on a U.S. satellite launched by France, Jason 1 is built around French and American instruments on a French satellite launched by the United States. Lofted from California's Vandenberg Air Force Base in December, Jason 1 continues observations of the global climate dance between the sea and the atmosphere. It will monitor world ocean circulation, study interactions of the oceans and atmosphere, improve climate predictions and observe events like El Niño.

Topex/Poseidon, meanwhile, spent the year delivering a picture of sea surface heights around the globe every ten days. Based on Topex/Poseidon data, oceanographers noted a pattern called the Pacific Decadal Oscillation continuing to dominate the entire Pacific basin as 2001 began. This pattern, revealed by a telltale horseshoe of warm water and a wedge of cool water, was good news; typically it acts as an El Niño repellent, giving the West Coast of the United States a milder, less-wet winter. The pattern continued throughout all of 2001.

Another JPL satellite, QuikScat, provided a team of scientists with data they used to establish how a relatively tiny chain of islands has a far-reaching effect on the world's largest ocean. Although the Pacific Ocean is dominated by steady westward trade winds and north equatorial current, they split when they reach the volcanic mountains of the Hawaiian Islands. Many islands produce a "wake" effect in wind or ocean currents, but the team of

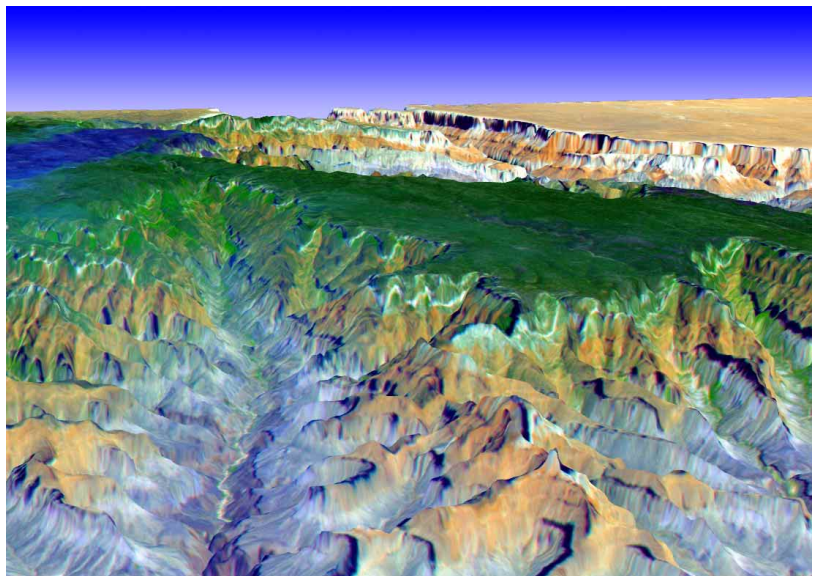


The QuikScat satellite, measuring ocean winds, made a discovery about the far-reaching influence of the Hawaiian Islands. (Right) A perspective view of the Grand Canyon was generated from data gathered by the Advanced Spaceborne Thermal Emission and Reflection Radiometer.

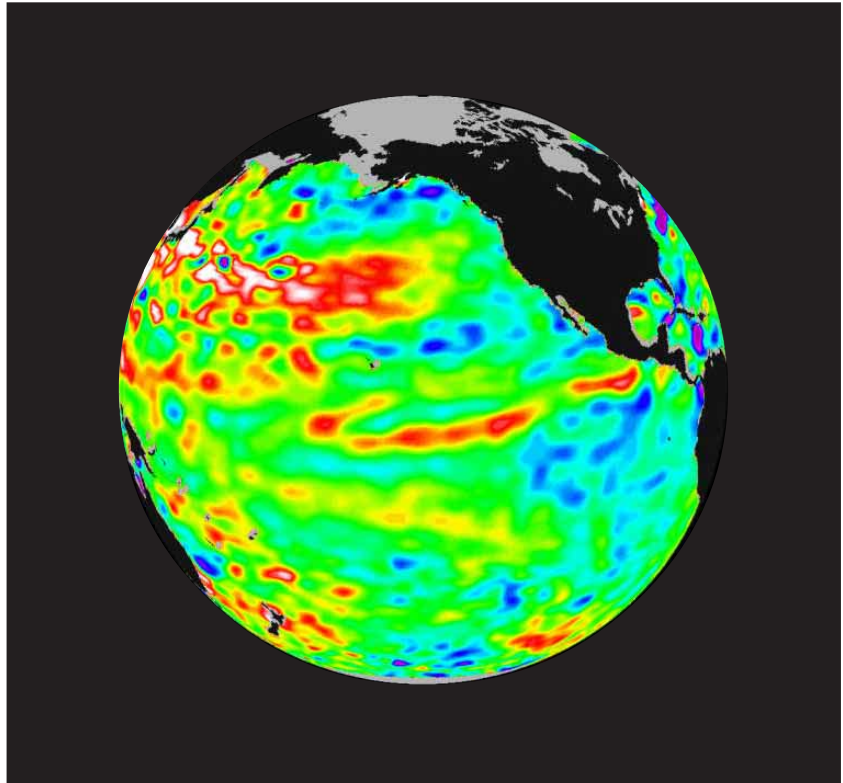
scientists found a remarkably long 3,000-kilometer (1,800-mile) wake streaming away from Hawaii – ten times longer than what conventional theory would predict. The wake includes a narrow eastward-flowing ocean current that may have helped early settlers reach the island chain from Asia.

Volcanoes were another focus for JPL Earth researchers. Instruments developed at the Laboratory, including radiometers, spectrometers and interferometers, were used to make detailed studies of the approximately 500 active volcanoes around the world. Data were provided by JPL's Multi-angle Imaging SpectroRadiometer and the Advanced Spaceborne Thermal Emission and Reflection Radiometer, both on NASA's Terra satellite, as well as observations by the Shuttle Radar Topography Mission flown on the space shuttle the previous year. JPL's imaging technicians pioneered the use of powerful animation software to visualize dynamic volcanic processes such as lava flows, ground deformation and the appearance and growth of hot spots.

While most Earth-imaging instruments fly in space, JPL scientists participated in a NASA field experiment using airplane-mounted instruments to better understand how hurricanes evolve and behave. The two NASA aircraft flew



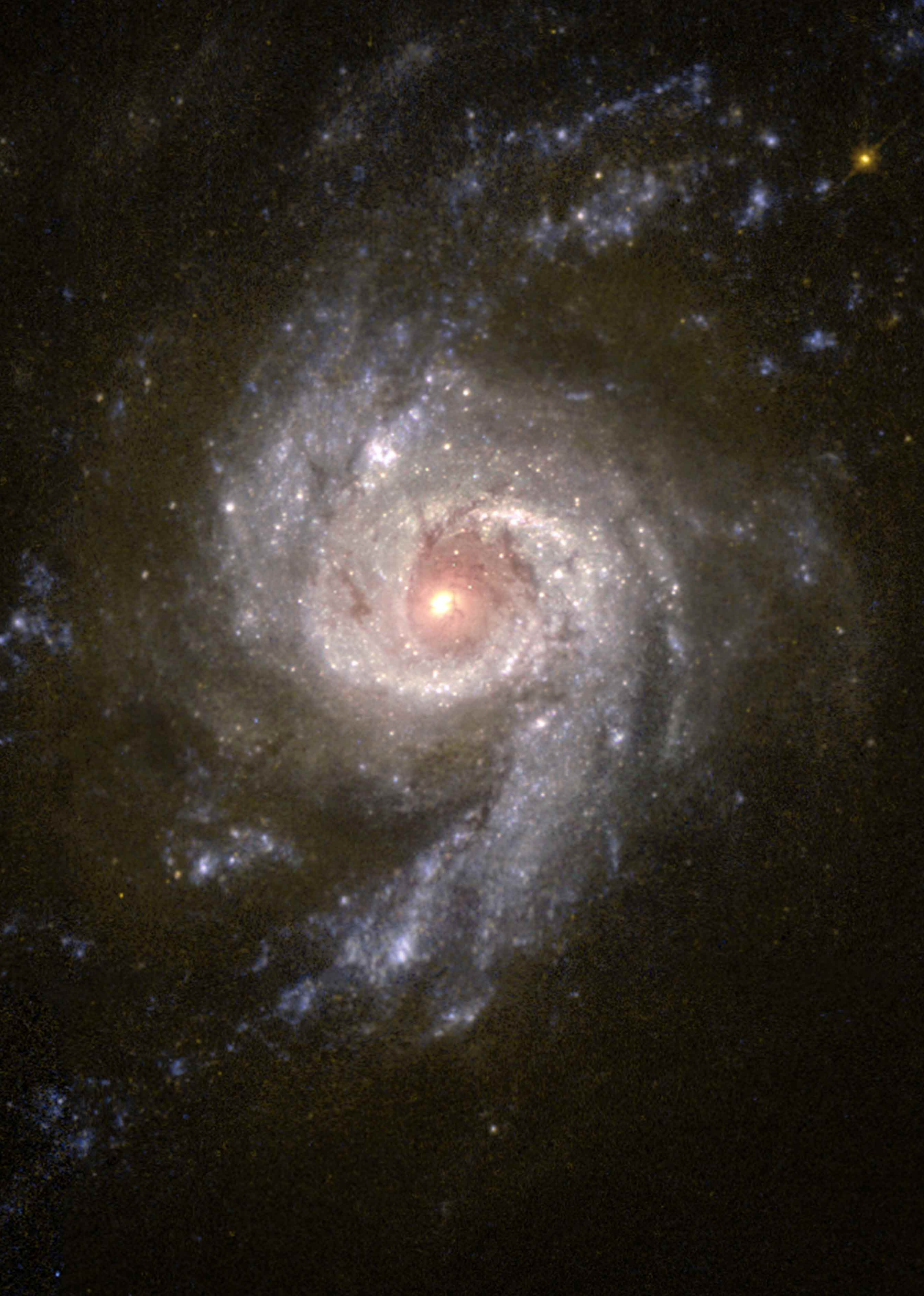
**T**opex/Poseidon continued to monitor sea-level heights, providing valuable temperature data. Red and white correspond to higher sea levels and warmer ocean temperatures.



over, through and around selected hurricanes in the Caribbean, the Gulf of Mexico and the Atlantic Ocean. The instruments included an advanced atmospheric microwave radiometer, a laser hygrometer for rapid measurements of water vapor, microwave temperature profiler instruments and a dual-frequency radar that measures the 3-D structure of rainfall.

Another airborne JPL instrument, Airborne Synthetic Aperture Radar, or *Airsar*, flies aboard a NASA DC-8. Data it collected were used by researchers in Alaska, who fused *Airsar* data to other satellite imagery to create a high-resolution digital elevation model of Umnak Island, home to the Okmok volcano. Before this, the most recent topographic map of the island dated to 1957 and was made from aerial photographs. Okmok has erupted four times since then, dramatically changing the landscape. This map will aid geologists in the analysis of surface deformation that indicates magma movement.

On a somber note, a JPL instrument was able to provide some assistance to disaster officials following the September 11, 2001, terrorist attack on the World Trade Center. The Airborne Visible/Infrared Imaging Spectrometer, or *Aviris*, was flown aboard a Twin Otter airplane at different altitudes to identify residual hot spots from fires. Another concern had been for the dispersion of asbestos into the environment as dust; *Aviris* was able to allay that concern.





As the Hubble Space Telescope celebrated its eleventh birthday, its main camera, JPL's Wide-Field and Planetary Camera 2, added image number 100,000 to its vast photo album.

## A S T R O N O M Y & P H Y S I C S

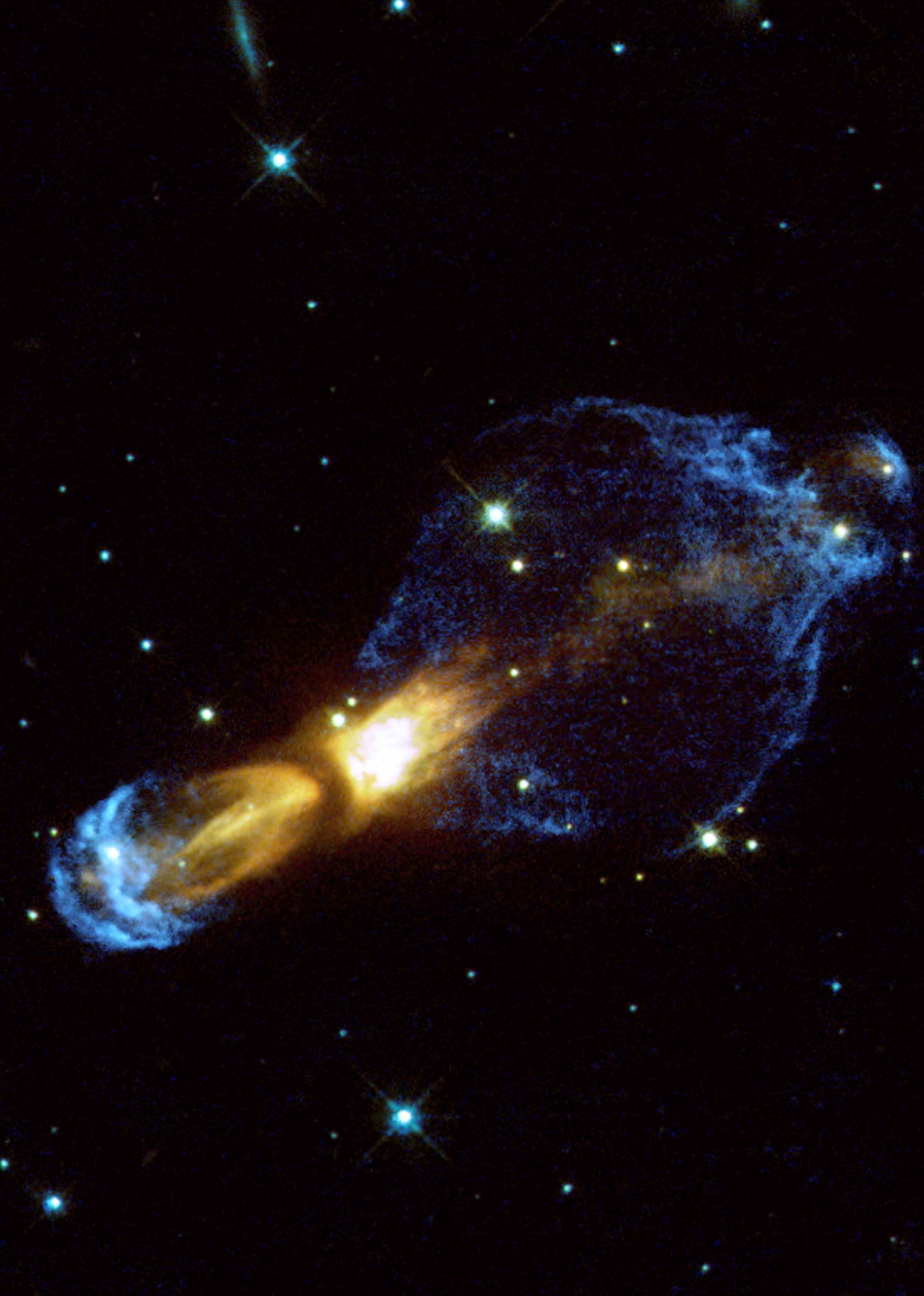
The Wide-Field and Planetary Camera 2 imaged the brilliant starburst galaxy NGC 3310, 59 million light years from Earth.

Among the views provided by the Wide-Field and Planetary Camera 2 in 2001: the Ant Nebula, which may shed light on the future demise of our Sun; unprecedented detail of the spiral arms and dust clouds in the Whirlpool galaxy; and some surprising, wandering, planet-sized objects inside the globular cluster M22. Some images were translated into Braille versions for a book designed for blind students.

The Two Micron All-Sky Survey, a project by JPL and other partners, finished its 3-1/2-year assignment of scanning the skies with a pair of infrared telescopes on the ground. This wraps up the most thorough census ever made of our Milky Way galaxy and the nearby universe; it yielded 24 terabytes of archive data.

First starlight was gathered by the Keck Interferometer, a pair of 10-meter (33-foot) telescopes atop Hawaii's Mauna Kea that were successfully linked to work in unison. Scientists plan to use this sophisticated telescope system to study dust clouds where planets may be forming, and to search for large planets. This will help pave the way for future planet-hunting missions, such as the Terrestrial Planet Finder.

Another ground-based interferometer, the Palomar Testbed Interferometer near San Diego, detected a case of celestial midriff bulge. The system directly measured the star Altair and found it was spinning so fast its mid-section had stretched out.



**V**iolent gas collisions

tearing apart a star were revealed by the Wide-Field and Planetary Camera 2.

Material ejected from the dying star has been accelerated in opposite directions at tremendous speeds, forming a beautiful planetary nebula.

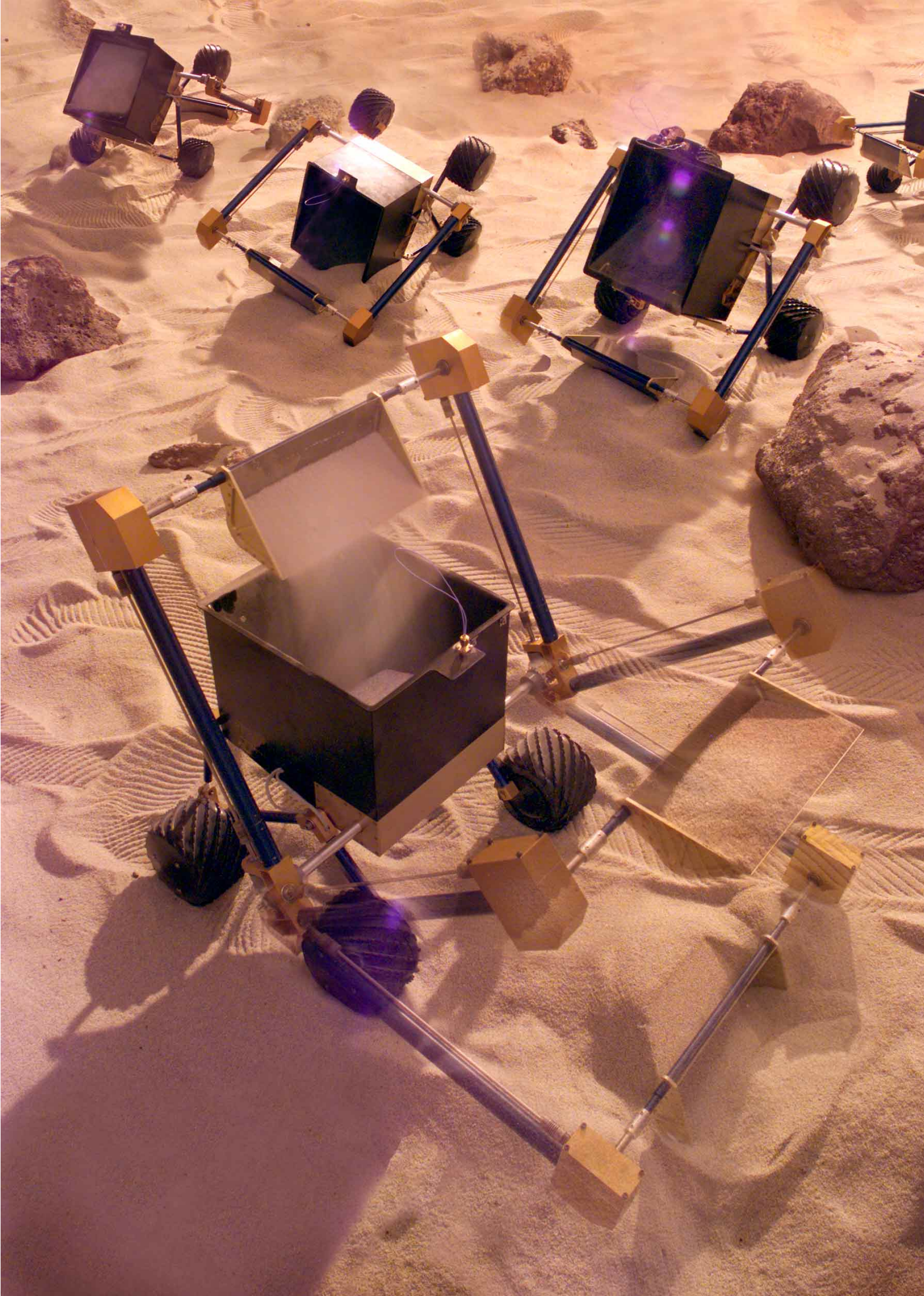
NASA selected a JPL team as one of four teams to be part of the agency's Astrobiology Institute. The focus of this national and international research consortium is the study of the origin, evolution, distribution and future of life on Earth and elsewhere in the universe.

It was a banner year for fundamental physics, with several important discoveries funded by NASA. JPL manages a program studying fundamental physics in the physical sciences for NASA's Office of Biological and Physical Research. NASA-funded scientists from the Massachusetts Institute of Technology spun ultracold sodium gas until it created a gas cloud riddled with tiny whirlpools. This phenomenon is similar to that which causes starquakes in space, puzzling glitches observed by astronomers in the rotation of pulsars. The scientist involved in this research shared the 2001 Nobel Prize for physics. The research may enable extremely precise measurements that could lead to microscopic computers and ultraprecise gyroscopes. Benefits could include dramatically improved aircraft guidance and spacecraft navigation.

Other scientists used lasers to cool a cloud of lithium atoms enough to observe unusual quantum properties of matter. Although current technology does not permit humans to travel to the stars, the scientists created a simulated star lab on Earth. They successfully simulated and photographed the process by which white dwarfs and neutron stars retain their size and shape, a mechanism called Fermi pressure.

In a process similar to watching water flow out of a faucet and then reverse direction, a JPL-led team used superfluid helium-4 in laboratory research that could improve earthquake prediction and spacecraft navigation.

Other researchers manipulated ultracold liquid helium-3 in a hollow, doughnut-shaped container to produce a whistling sound that varied depending on its orientation relative to the North Pole and Earth's rotation. This may eventually help measure how clouds and earthquakes change Earth's rotation.



As a national laboratory, JPL puts its technological expertise to work not only on behalf of NASA but also to solve challenges on the ground. Many examples of these “spinoffs” from space research came to the forefront in 2001.

## T E C H N O L O G Y

**G**roups of small, lightweight, intelligent rovers with “bulldozer” scoops may support future Mars missions by digging samples for analysis or excavating terrain.

Thanks to a partnership between the Laboratory and a tractor manufacturer, space age technology will be used to help farmers. Tractors will be equipped with receivers that provide instant location information, allowing farmers to navigate fields at night and when visibility is poor. Using soil sensors and other monitors, it will let farmers calculate exactly when their fields need more water, fertilizer and weed control – thus saving them time and money. The system combines software developed by JPL and data from the Department of Defense’s constellation of Global Positioning System satellites.

JPL continued to bring the benefits of the space program to American industry in other ways. A new radar mapping technology designed to generate high-resolution, three-dimensional maps of Earth beneath foliage and other vegetation has been licensed by JPL to a private company. This will be the first system that will be able to map above, through and below the vegetation canopy, providing important information such as data about landslides that are overgrown with vegetation. The system will be able to operate both day and night, under almost any weather condition. The data will also help in land-use planning, environmental protection, flood plain management and other geographic analyses.

In the forefront of nanotechnology development, JPL acquired one of the world’s finest electron-beam lithography systems, one that will allow researchers to work at the equivalent level of nature’s biological building blocks. Lithography is the process of printing a pattern onto a surface,

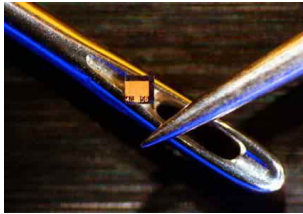
**A**n ice-penetrating cryobot and a submersible hydrobot could be used to explore Jupiter's satellite Europa, which may harbor an ocean beneath its icy crust.



such as a silicon chip or a high-resolution film. For NASA, it means breakthroughs in miniaturization that could lead to significant reductions in the mass and cost of spacecraft to look for traces of life on distant planets. For researchers, it means access to one of only three such systems in the world, and the only one in the public sector devoted to pure research for building the nanoscale devices of the future.

Artificial intelligence remained alive and well at JPL. Engineers created software that thinks for itself and makes decisions without help from ground controllers. The software will function much like a brain and use inputs from sensors that approximate human eyes and ears to make decisions. It was scheduled to fly in 2002 as the brains of a constellation of triplet miniature satellites, each weighing less than 15 kilograms (33 pounds).

JPL robotics research took form into all shapes and sizes. Researchers worked on the next generation of air, surface and subsurface vehicles for exploration of other worlds, including Mars, Venus, Jupiter's moon Europa



**S**smaller than the eye of a needle, this high-performance diode laser can be tuned like a radio to specific frequencies, enabling it to operate as a gas sensor for climate research.

and Saturn's largest moon, Titan. The vehicles included a tumbleweed ball, which can blow with the wind; blimps; and all-terrain rovers, which can traverse steep hills and gullies.

The latest creations from Laboratory engineers were tiny bulldozer rovers that may some day dish up the dirt and pack it in on Mars. The scoop-and-dump design of a prototype bulldozer rover mimics that of a bulldozer and dump truck. Unlike life-size bulldozers and dump trucks, which can weigh several thousand pounds, these rovers are lightweight, intelligent and can work without an operator at the wheel. Yet they have the same capabilities, relative to their size, as their heavy-duty counterparts. Robotics engineers think the basic research on these bulldozing rovers may support future missions to look for life or to sustain a human presence.

Within this nexus of robotics research, JPL engineers and staff members still found time to mentor high school students on the ins-and-outs of building their own robots. The Laboratory sponsored more than 20 high school teams who took part in a regional robotics competition where student-built robots rub metal, burn rubber and duke it out. Unlike other competitions, this competition call for teams to build alliances and work together to score points.



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TRACK CON 4

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The giant antennas of the Deep Space Network supported a wide assortment of missions in 2001. In addition to the many spacecraft managed by JPL, the network was the communication liaison for other exciting NASA events such as the landing on asteroid Eros by the Near Earth Asteroid Rendezvous spacecraft.

## DEEP SPACE NETWORK



**A**dvanced technology antennas at Goldstone, California, part of NASA's Deep Space Network. (Left) The Deep Space Operations Center at JPL.

Construction was begun on a set of Deep Space Network upgrades to prepare for meeting a foreseeable jump in demand for interplanetary communications services beginning in late 2003. A new advanced-technology dish antenna 34 meters (112 feet) in diameter is being added at the network's complex in Madrid, Spain. Other aspects of the upgrade project will improve capabilities at all three of the network's complexes in California, Spain and Australia.

Looking further ahead, JPL engineers have begun planning how to organize an "interplanetary Internet" communications infrastructure that would serve a continuous and ever-growing exploration presence at other planets.

Deep Space Network antennas are also used for radio astronomy and radar studies of the solar system. In 2001, astronomers used the powerful radar transmitter on the 70-meter (230-foot) antenna at the network's complex at Goldstone in the California desert to examine detailed movements of two asteroids that orbit each other, the asteroid pair 1999 KW4.

JPL partnered with the Lewis Center for Educational Research in Apple Valley, California, to enable students in high school and younger grades around the country to operate a decommissioned 34-meter (112-foot) antenna at Goldstone as a radio telescope. Remotely controlling the telescope from their classrooms, the students contributed to a coordinated set of ground-based observations as the Cassini spacecraft flew past Jupiter in the winter of 2000–2001. New discoveries about the nature of the radiation belts were made from radio maps made from data collected by Cassini and the students.



The most significant change for JPL as an organization was the arrival of a new director to lead the Laboratory. Dr. Charles Elachi, a scientist with a background in imaging radar and other remote-sensing technologies, assumed the helm of JPL on May 1.

## I N S T I T U T I O N A L



The Laboratory anticipates exciting new challenges in developing missions to enhance understanding of our solar system and its planets, and to probe beyond in the quest to find and explore neighboring solar systems.

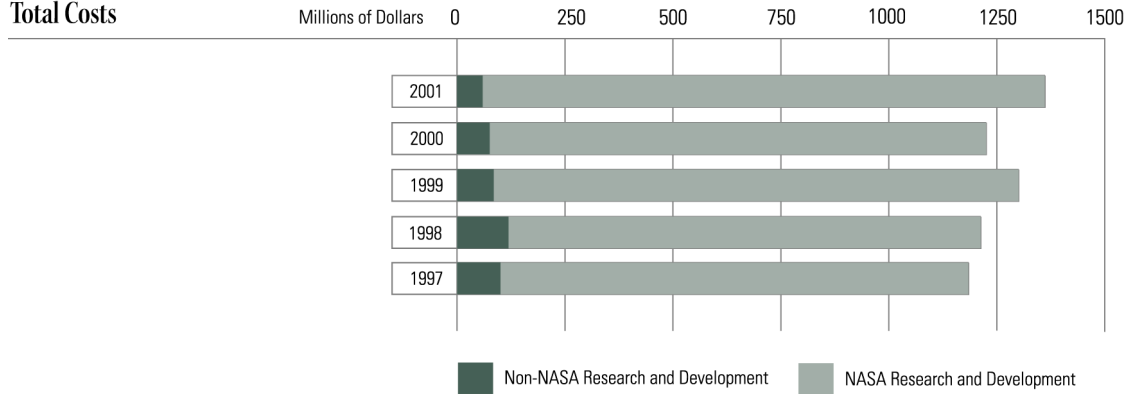
A 30-year employee of the Laboratory, Elachi served as project scientist for imaging radar instruments flown on the space shuttle before assuming an executive role over space missions and instruments in the 1990s. He succeeded Dr. Edward C. Stone, who led JPL for ten years; Stone returned to the Caltech campus to teach, conduct research and continue his duties as project scientist for the long-lived Voyager mission and for NASA's Advanced Composition Explorer.

To join him in guiding the Laboratory, Elachi recruited as deputy director Eugene L. Tattini, a lieutenant general who retired after nearly 36 years of service with the Air Force, most recently as commander of the Space and Missile Systems Center at Los Angeles Air Force Base. Tattini succeeded Larry N. Dumas, who retired after serving as deputy director for nine years.

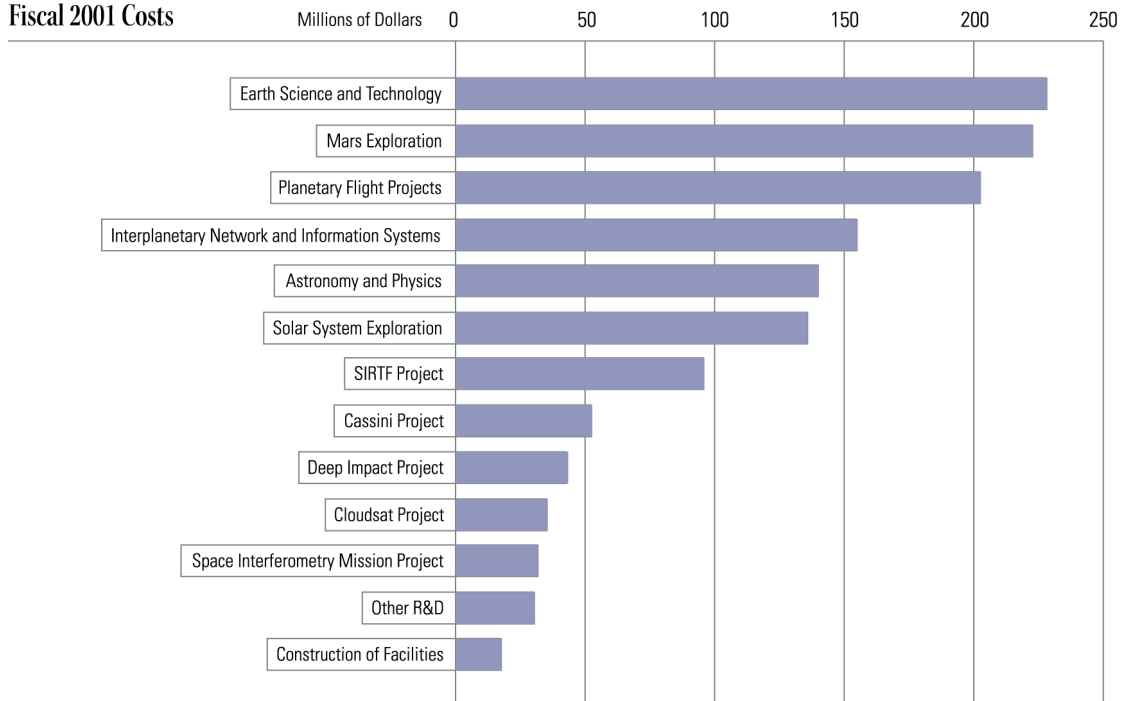
Immediately upon starting his new position in May, Elachi announced a reorganization to strengthen and simplify JPL's structure. Among the changes were appointment of a new chief scientist; creation of a new senior executive position to oversee designing and building of spacecraft; addition of a chief technologist position; and realignment of offices responsible for JPL's missions in solar system exploration, Earth sciences and astronomy and physics.

For fiscal year 2001, JPL had approximately 4,690 employees and 532 on-site contractors, and a business base of approximately \$1.3 billion.

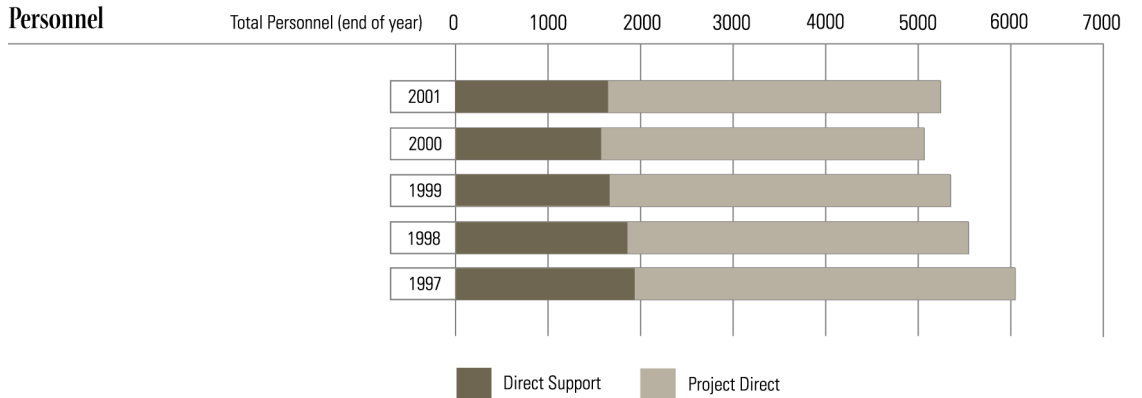
### Total Costs



### Fiscal 2001 Costs



### Personnel



2011

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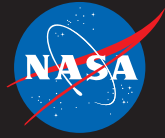
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