National Aeronautics and Space Administration

JET PROPULSION LABORATORY

Annual Report 08

National Aeronautics and Space Administration

Jet Propulsion Laboratory
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Cover: A panorama of the Phoenix spacecraft's landing site on Mars, combining more than 400 images taken during the first few weeks after it reached the Red Planet in May 2008.

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08 Director's MESSAGE

"It is good to love the unknown," a thinker wrote two centuries ago. That could be the motto of the Jet Propulsion Laboratory. Every day, our job is to work on the outer edge of what humans collectively know. All you have to do is to look at the science that has flowed from our missions to realize how much we take for granted today was unknown just a few years ago. In less obvious ways, our engineers engage the unknown as much as our scientists do — creating machines, thrusting them into alien environments and pushing them far beyond normal limits.

Nothing is more exciting than when science mines the far end of our knowledge for the new and the unexpected. In 2008, the world was taken by surprise when JPL astronomers announced the discovery of organic compounds on a planet orbiting another star. We were equally excited to learn from the Spitzer Space Telescope that many, if not most, sun-like stars have rocky planets roughly similar to Earth. Together these are very intriguing clues in our quest to learn if there is life elsewhere in the universe — which certainly has to be one of the most profound mysteries of our age.

As many times as we have studied Saturn with spacecraft, the Cassini orbiter is proving that the ringed planet and its moons in many ways remain unknown worlds. As yet another scrap of evidence in the search for the stuff of life outside Earth, Cassini found a surprising brew of complex organic compounds in the geysers that erupt from the surface of Saturn's icy moon Enceladus. Discoveries like this could not be foreseen when the mission was first conceived and built.

Sometimes in science we know the big picture, but the unknowns are the underlying mechanisms that cause it to be. Our Earth-orbiting satellites, such as Jason 2 that launched in 2008 on the Ocean Surface Topography Mission, have powerfully established that what theorists say is true: human activities are causing global climate change that may reach a point where irreversible effects occur. What our missions continue to discover and document is how those changes are taking place — the chemistry and the physics responsible. These could help point the way to what needs to be done to heal the trends.

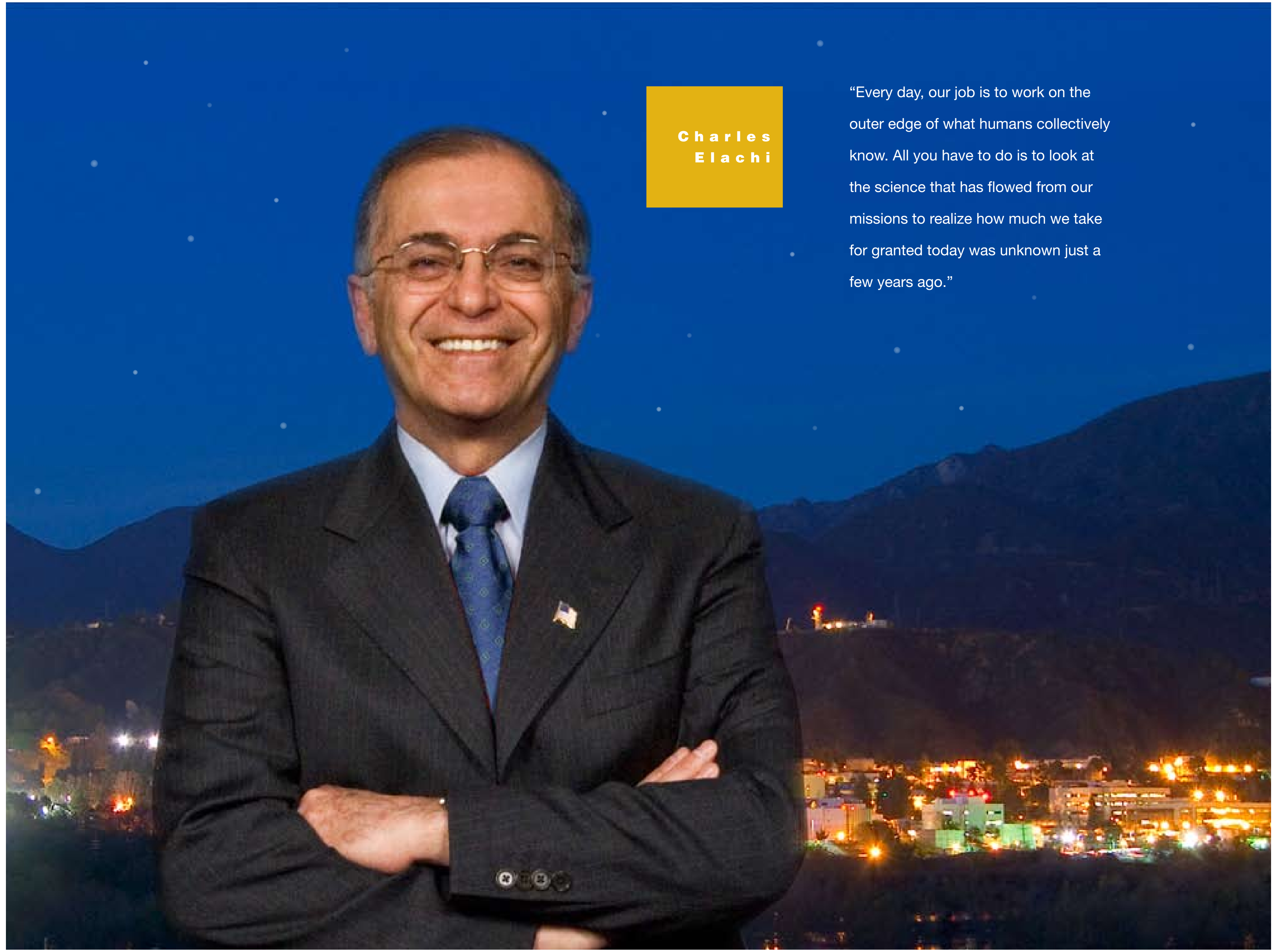
But the unknown is as much a preoccupation of engineers who design flight systems and technologists who create innovative devices. When devising machines as complex as our robotic spacecraft, there are never any certainties about how they will perform and how well they will endure. Project teams live in a realm in which there are no assurances, but instead calculations of risk. Every time we launch a spacecraft or land one on another world, we still hold our breath. This makes us relish the success that much more when things go well, as they did when the Phoenix lander settled down on the frozen plains of the Martian arctic last May.

There are times when, dealing with unknowns, we are reminded to be humble. I was terrifically impressed by the progress that the team developing our next flagship mission, Mars Science Laboratory, made during the year. But I equally respected their judgment when, toward the end of the year, they concluded it would not be safe to try to fly during the Mars launch window in 2009, and reset for the next opportunity in 2011. We are not in the business of pursuing the predictable; if there were no surprises, I would suspect we are not pushing the envelope hard enough.

We are lucky to have valuable assets that support us as we venture into the unknown. One is the global Deep Space Network, which functions both as our communication gateway to our spacecraft across the solar system as well as a research tool itself in conducting radar astronomy. Our successes depend on our entire team — administrators and business specialists as much as technical people. There are those who help share our missions with the public, finding imaginative venues such as sending out dispatches on the Internet's Twitter.com during the Phoenix mission. We also benefit greatly from the intellectual infusion that comes from our unique identity as a division of the California Institute of Technology and a member of the NASA family.

There are of course an unlimited number of unknowns still ahead of us. This is what keeps our work constantly self-renewing, always challenging and inspiring. In this annual report we have taken a new direction, recounting our accomplishments in 2008 month by month. I hope you will enjoy this look at what our JPL explorers have accomplished, and that you will join us as we both discover and create the future every day.

CHARLES ELACHI

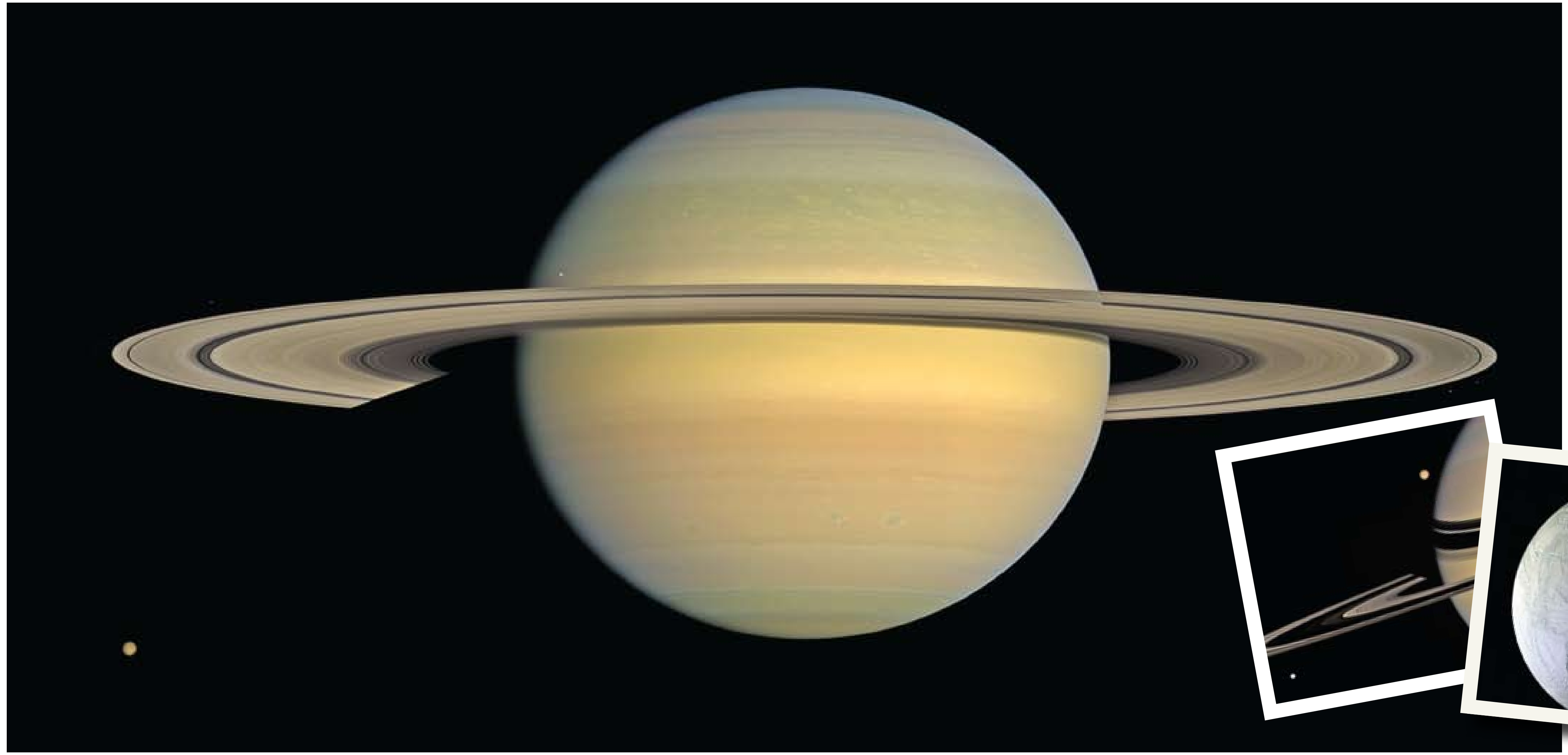


"Every day, our job is to work on the outer edge of what humans collectively know. All you have to do is to look at the science that has flowed from our missions to realize how much we take for granted today was unknown just a few years ago."

January 08

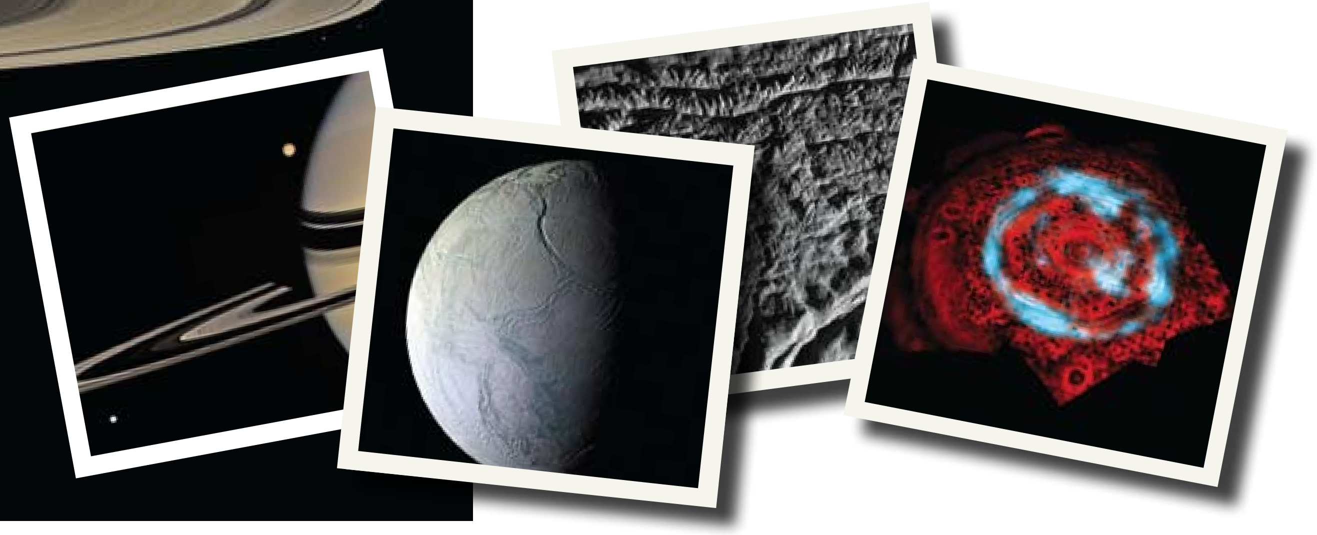
LIFTING the VEIL

After four years orbiting Saturn and dozens of encounters with its moons, Cassini-Huygens mission fans might wonder if it had seen all there was to see — but 2008 served as a reminder that familiar neighborhoods can still hold surprises. Much of the news sprang from two of Saturn's moons — the large, haze-shrouded Titan, and the small, unexpectedly active Enceladus — which the spacecraft focused on during its 14 flybys, beginning with a January 5 encounter of Titan. In one particularly close encounter, Cassini sailed through one of Enceladus' watery geysers as if it were a water-park attraction; the daring maneuver revealed a surprising mix of complex organic compounds spewing from the moon. In another flyby, Cassini pinpointed exactly where the icy jets erupt on Enceladus in fractures that scientists likened to tiger stripes. Scientists debated whether the water-rich geysers could spring from liquid water under the moon's surface; if there is liquid water on Enceladus, that plus the organics could provide the ingredients for simple life. The much larger Titan, meanwhile, was found to harbor hundreds of times more liquid hydrocarbons than all of the known oil and natural gas reserves on Earth. Some scientists speculated as well that an ocean of water and ammonia could exist beneath Titan's frozen exterior — an increasingly common scenario on the moons of the solar system's giant outer planets. By summer, Cassini wrapped up its four-year primary science mission, and set about a two-year extended mission with Titan and Enceladus continuing as the star attractions.



The hues of Saturn's atmosphere have gradually evolved during Cassini's four years in orbit. Due to the planet's orbit, more sunlight fell on the northern hemisphere in 2008, shifting colors there from azure blue to a multitude of muted-colored bands (left).

Views from Cassini included (from left) moons Titan and Tethys flanking the rings; the geologically active moon Enceladus; close-ups of curving fractures on Enceladus' surface; and a glowing aurora at Saturn's north pole.



Quick Takes

Surprising findings on how stars explode were yielded by the **Keck Interferometer**, a new JPL-built system that links two telescopes at the Keck Observatory on Hawaii's highest mountain, Mauna Kea. Using the paired telescopes, one team observed an exploding star, or nova, in the constellation Ophiuchus ("The Snake Holder"). Astronomers previously thought the dust they see around the star was fallout from the cosmic explosion, but the new finding shows the dust was there before the star blew apart.

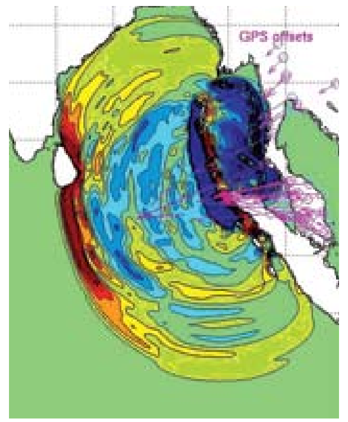
> Cassini's compelling discoveries help students feel the intellectual excitement that motivates real scientists.
>
> NATIONAL SCIENCE TEACHERS ASSOCIATION

SPACECRAFT on MAIN STREET

In the 1950s, the sight of a spacecraft on Main Street might have provoked notions of hostile aliens and *The Day the Earth Stood Still*. In 2008, it was strictly an homage to JPL's role in opening America's space age when a replica of the Explorer 1 satellite glided down Pasadena's Colorado Boulevard. The occasion was the Rose Parade, and the JPL–Caltech float took advantage of it to celebrate the 50th anniversary of the 1958 launch of the historic JPL satellite. The float doffed its hat as well to the many spacecraft that followed over the decades since JPL led the first wave of exploration of the solar system.

TSUNAMI WARNINGS

A rumble in the distance can have life-threatening consequences, if the shaking sets off a tsunami like the destructive wave that killed hundreds of thousands in Indonesia four years ago. Yet not every earthquake near the ocean spawns such moving water — and technology can help tell the difference. JPL researchers demonstrated a far-flung network of Global Positioning System receivers — cousins of the devices that tell motorists which turns to make to get to their destinations — that can render enough advance warning of such events to allow coastal areas to evacuate. The tsunami detection system significantly improves on traditional ways of predicting tsunamis by measuring earthquakes.



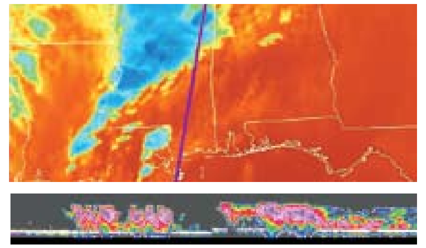
Working with colleagues at Southern California's City of Hope cancer center, JPL technologists have been using tiny tubes 50,000 times narrower than a human hair called **carbon nanotubes** to try to diagnose and treat brain tumors. The microscopic vessels can be used to deliver cancer-fighting chemicals to brain cells, helping to boost the brain's own immune response. If effective, the technology might also be used to treat other disorders and disease processes in the brain.

February 08

ACROSS the UNIVERSE

Beyond the daily duty of communicating with spacecraft across the solar system, the antennas of the Deep Space Network also took practical and fanciful turns — as a radar instrument to probe the moon, and as a tool to deliver a song to the stars. Mountaineering gear may be in order for future human explorations of the south pole of Earth's moon, which was revealed in new radar images to host peaks as high as Mt. McKinley and crater floors twice as deep as the Grand Canyon. At the Deep Space Network's Goldstone complex in California's Mojave Desert, researchers bounced radar signals off the moon to create the highest-resolution terrain maps ever made of the mountainous region on Earth's natural satellite. Meanwhile, back on Earth the Deep Space Network took a spin as deejay to E. T. In a historic interstellar broadcast, one of the network's antennas beamed the Beatles song "Across the Universe" toward the North Star, Polaris, to celebrate multiple anniversaries — the 40th anniversary of the song's recording, the 50th anniversary of Explorer 1 and the founding of NASA, and the 45th anniversary of the founding of the Deep Space Network. Former Beatle Paul McCartney and Yoko Ono, widow of John Lennon, sent congratulatory messages. Traveling at the speed of light, the radio signals will take 431 years to reach Polaris.

Quick Takes

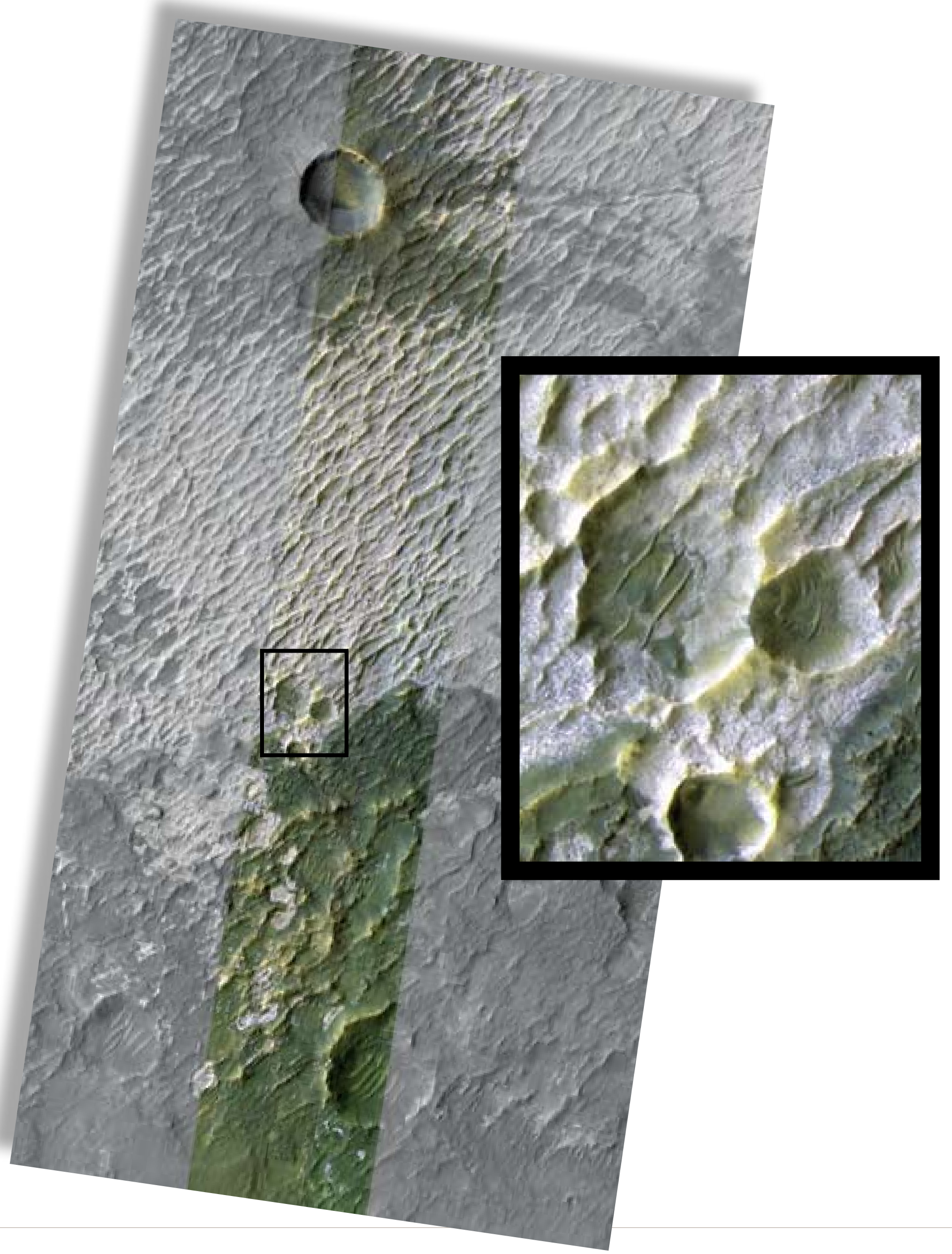


An outbreak of tornados over Kentucky, Tennessee and Mississippi on February 5 was caught by the **CloudSat satellite** as it made a nighttime pass over the region. The twisters, spawned along a front of intense thunderstorms, caused more than 50 deaths and billions of dollars in damage. Launched two years previously, CloudSat completed its primary science mission in 2008.

March 08

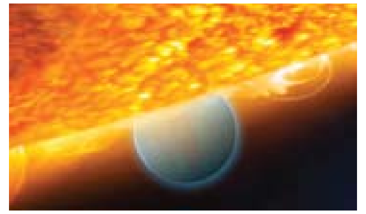
The SALT of LIFE

There's a salty story to be told on Mars — but that's not to say it will make anyone blush. In March, scientists told of using the thermal emission imager on the Mars Odyssey orbiter to discover hundreds of spots around the planet with evidence of salt deposits. Those are locales, they concluded, where water was abundant on ancient Mars. Later in the year, mapping of elements such as potassium, thorium and iron by Odyssey's gamma-ray spectrometer offered new evidence supporting a controversial theory that oceans once covered about a third of ancient Mars. Throughout 2008, Odyssey played a key role relaying data to Earth for the twin Mars Exploration Rovers. In the fall, Odyssey shifted its orbit to commence a new extension of its mission at the Red Planet, which it has orbited since 2001.

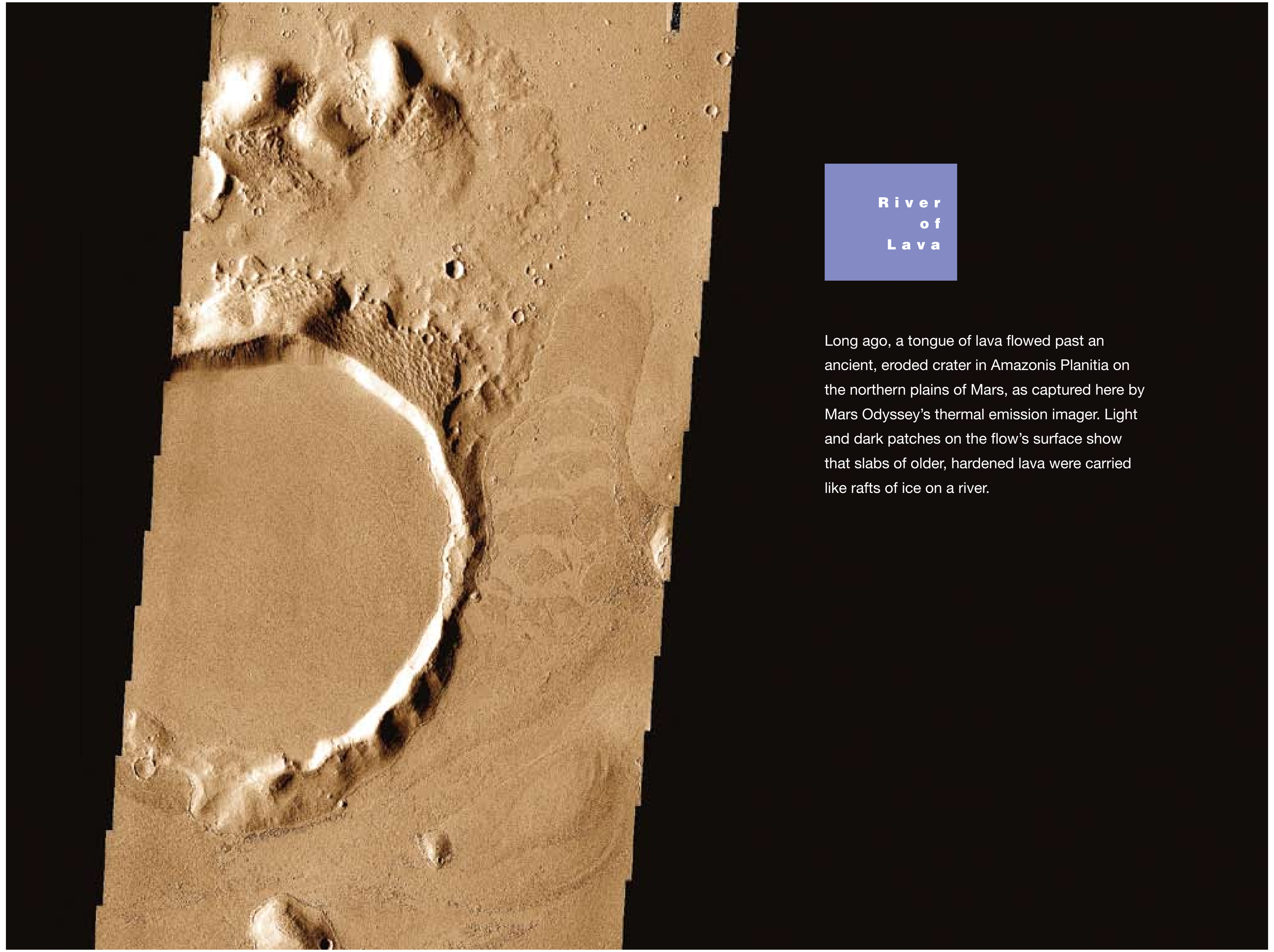


After the thermal imager on Mars Odyssey identified salt deposits in the Terra Sirenum region, the high-resolution camera on Mars Reconnaissance Orbiter followed up with an image (right, with closeup in inset). Salt deposits appear bright.

Quick Takes



The first-ever detection of an **organic molecule on a planet orbiting another star** was announced by a team led by a JPL astronomer. Using the Hubble Space Telescope, the scientists found methane, the main component of natural gas, in the atmosphere of a Jupiter-sized planet 63 light-years away in the constellation Vulpeca. That planet is too hot for life as we know it, but the finding suggests that the building blocks of life are common in the universe. At left, an artist's rendering of a planet orbiting another star.



River of Lava

Long ago, a tongue of lava flowed past an ancient, eroded crater in Amazonis Planitia on the northern plains of Mars, as captured here by Mars Odyssey's thermal emission imager. Light and dark patches on the flow's surface show that slabs of older, hardened lava were carried like rafts of ice on a river.

April
08

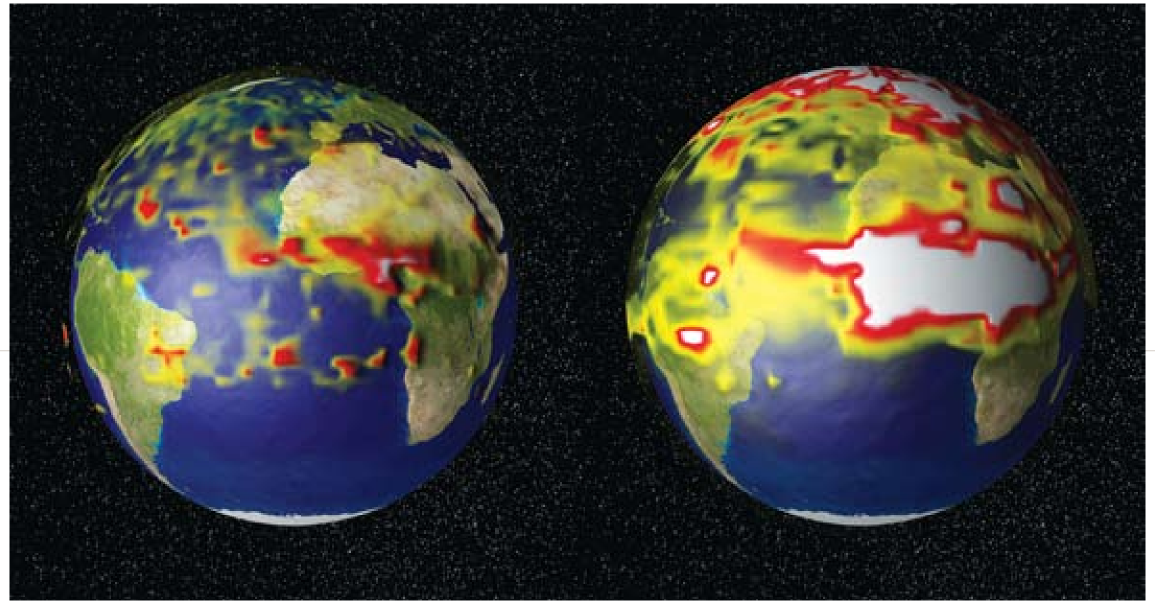
FEEDING BABY STARS

Common wisdom is that nurseries of infant stars are usually replete with dust and gas that nourish the newborn suns. Yet the Galaxy Evolution Explorer found baby stars sprouting in a desolate region far from the center of the Southern Pinwheel galaxy, an area comparatively devoid of the star-building resources usually found around infant stars. Astronomers speculated that the infant stars forming so far out from the galaxy's center could have been born under conditions that mimic those of the early universe, a time when space was not yet enriched with dust and heavier elements. April marked five years that Galaxy Evolution Explorer has been in space, capturing portraits of hundreds of millions of galaxies in ultraviolet light.

Outlying regions around the Southern Pinwheel galaxy, or M83, in a composite image from Galaxy Evolution Explorer and the Very Large Array in New Mexico.

Observations by JPL's Tropospheric Emission Spectrometer instrument "help clarify a significant uncertainty in the climate-change picture."

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH



REALITY CHECK

It's one thing to create models of how climate change could be changing the planet — but are they true? One JPL instrument, the Tropospheric Emission Spectrometer on NASA's Aura satellite, provided an important reality check in April. Scientists used the instrument to measure the greenhouse effect — how much heat energy is being reflected back to Earth by gases in the atmosphere. The instrument found that the energy emitted by ozone in the troposphere, the lowest part of the atmosphere, was a good fit to the numbers predicted by theorists in their models. Maps of global distributions of ozone (left) and carbon monoxide (right) delivered by the Tropospheric Emission Spectrometer.

May 08

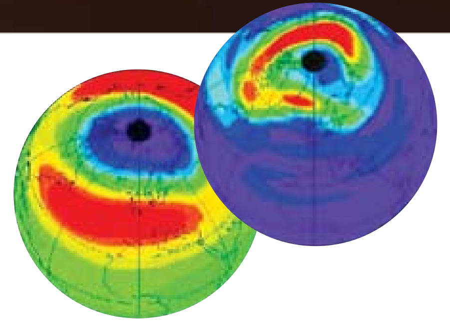
DIGGING DITCHES

There were plenty of held breaths at JPL and elsewhere, but when the dust settled — literally — the news couldn't have been better: The Mars Phoenix lander executed what can only be described as a textbook touchdown when it settled onto the frozen terrain near the planet's north pole on May 25. At once a ditch-digger and high-tech lab, Phoenix spent the next five months trenching and transporting scoops of soil to eight small onboard ovens where they were cooked to reveal their chemical composition. Other samples were conveyed to other onboard instruments for additional tests. Throughout the mission, as Mars' summer midnight sun gave way to the lower light levels of autumn, the lander took copious pictures and gathered daily weather readings. Its main finding? What Mars orbiters had seen from afar was in fact true — there's a phenomenal amount of water locked up in the form of ice near the Martian north pole. Since the planet's atmosphere is so tenuous, water can't exist in liquid form — it passes directly from solid to gas when it warms. But millennia ago, a similar lander would have perhaps splashed down on what is now tundra. Phoenix's findings added to the mounting evidence that Mars was probably once a warm, wet planet where life might have taken hold.

The Phoenix lander's handiwork is reflected in the trenches it dug on Mars (left). Scientists lent nicknames to the trenches, including the early Dodo and Baby Bear (near left). Project Manager Barry Goldstein celebrates the successful landing (far left).

Quick Takes

Pollution in clouds may interfere with normal rainfall, data from the **Microwave Limb Sounder instrument** on NASA's Aura satellite and other Earth-observing spacecraft revealed. One team measured the level of carbon monoxide in clouds, probably caused by smoke from sources such as power plants or agricultural fires. They concluded that South American clouds infused with airborne pollution produce less rain than their "clean" counterparts during the region's dry season.

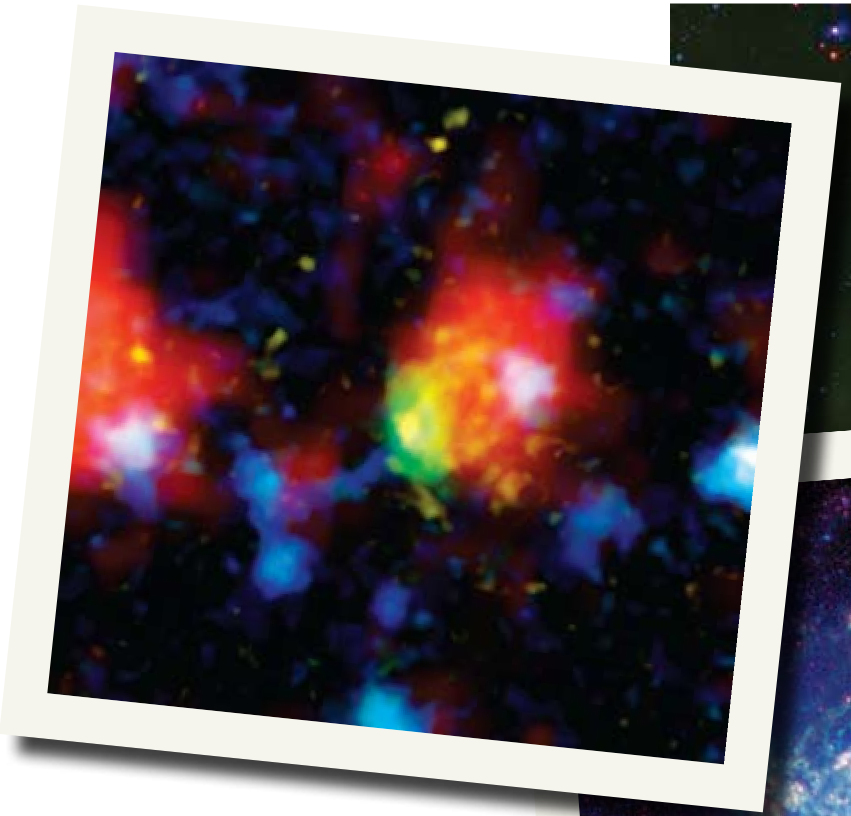


The skyline at JPL's campus on the edge of Southern California's San Gabriel Mountains took on a new feature in May as the final piece of steel was installed in the structural framework of the Laboratory's new **Flight Projects Center**. The nearly 200,000-square-foot building housing 620 offices, 20 conference rooms and a 450-seat auditorium boasts many energy-saving features and was slated for occupancy in the summer of 2009.

June
08

COSMIC SURPRISES

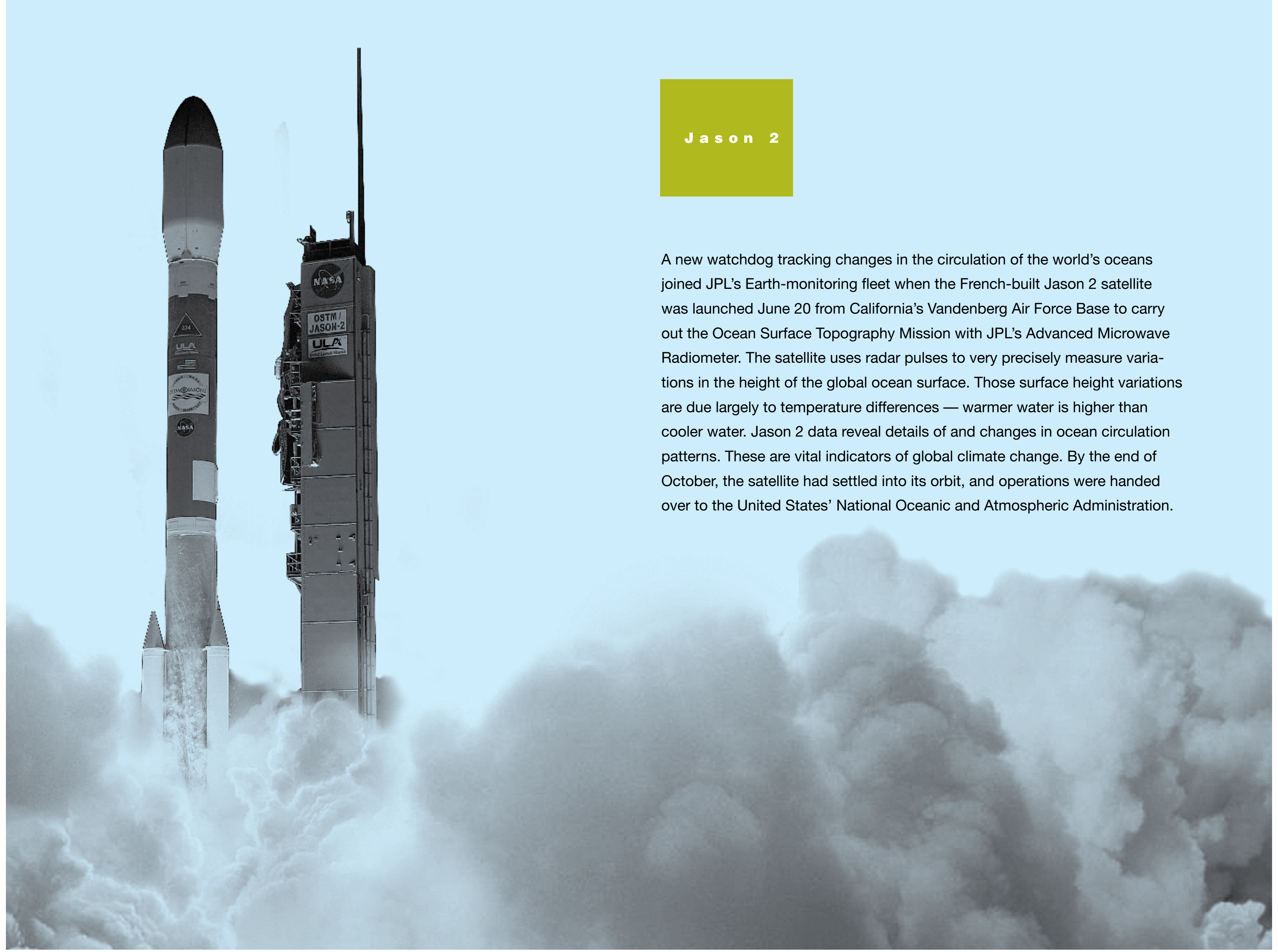
Though getting toward the end of its supply of precious coolant that makes its mission possible, the Spitzer Space Telescope had as full an agenda as ever in 2008, capturing richly varied observations of galaxies, nebulas, protostars and other exotic objects. Observations of our own Milky Way galaxy held many surprises. In June, astronomers used Spitzer images to show that the elegant spiral structure of our galaxy is dominated by just two arms — not the four that were thought to exist — extending from the ends of a central bar of stars. Piercing through opaque interstellar dust, Spitzer images of the inner Milky Way yielded a multi-generational family portrait of the inner galaxy's occupants, from embryonic and newborn stars to their dead and dying ancestors growing cold nearby. Other high points of 2008 included a memorable view of infant stars in a baby blanket of dust; a discovery that thin galaxies often grow fat black holes; and the remnants, or "light echoes," of a star that blasted apart in a supernova explosion. Spitzer also proved itself to be a valuable tool in searching out and studying exo-planets — planets orbiting other stars — a role that wasn't in its original job description. By early 2009, engineers estimate Spitzer will have depleted its supply of coolant that keeps its infrared detectors close to absolute zero in temperature. With its retirement date near, plans call for Spitzer to continue on in a "warm mission" where it will use its imagers in different ways to ponder new kinds of targets.



Newborn stars peek from beneath a blanket of dust in a portrait of the Rho Ophiuchi dark cloud from the Spitzer Space Telescope (right background). Left, Spitzer views of a distant star-making galaxy nicknamed Baby Boom (left) and the Pinwheel galaxy, or M101.

Quick Takes

Wildfires may have a wider and longer effect than previously realized, data from JPL's **Multi-angle Imaging SpectroRadiometer** instrument on NASA's Terra satellite suggested. On June 27, the instrument captured images of 250 fires burning across tens of thousands of acres of timberland in Northern California. Those views showed wildfire plumes injecting smoke above the layer of the atmosphere closest to Earth into the free troposphere, where it can linger and travel far from its source.

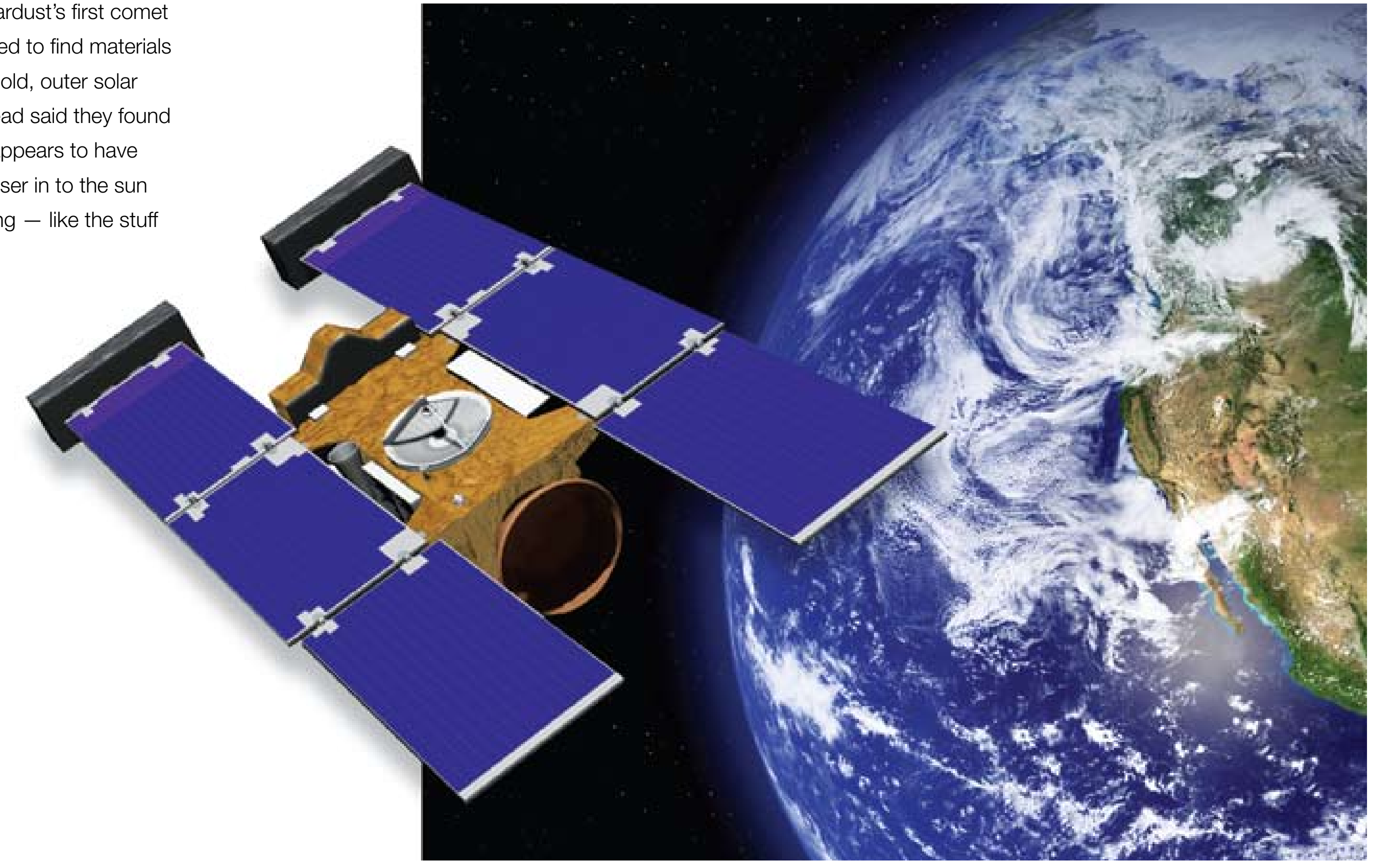


Jason 2

A new watchdog tracking changes in the circulation of the world's oceans joined JPL's Earth-monitoring fleet when the French-built Jason 2 satellite was launched June 20 from California's Vandenberg Air Force Base to carry out the Ocean Surface Topography Mission with JPL's Advanced Microwave Radiometer. The satellite uses radar pulses to very precisely measure variations in the height of the global ocean surface. Those surface height variations are due largely to temperature differences — warmer water is higher than cooler water. Jason 2 data reveal details of and changes in ocean circulation patterns. These are vital indicators of global climate change. By the end of October, the satellite had settled into its orbit, and operations were handed over to the United States' National Oceanic and Atmospheric Administration.

ON to ACT II

Can there be an Act II after a career-topping event? There's one in store for the Stardust mission. After flying by comet Wild 2 in 2004 and bringing samples of comet dust back to Earth in 2006, the spacecraft is preparing for a sequel in the form of a visit to another comet, Tempel 1, in 2011. The new flyby will give scientists a close look at the crater blasted in the comet by another spacecraft, Deep Impact, four years ago. On June 25, Stardust fired its thrusters to tweak its flight path for the upcoming comet encounter; later in the year, it activated its thrusters again to set the stage for a flyby of Earth in January 2009 en route to the comet. Back at home, meanwhile, scientists announced they were surprised by what they saw in the samples from Stardust's first comet visit. They expected to find materials dating from the cold, outer solar system, but instead said they found much dust that appears to have formed much closer in to the sun when it was young — like the stuff of asteroids.



How much is climate change reshaping the planet? Answers are a few keystrokes away, at the new **Global Climate Change website** (http://climate.jpl.nasa.gov). The site offers a continuously updated, dashboard-style snapshot of the planet's health, built from NASA data on such climate indicators as the condition of Earth's ice sheets, global average temperatures, sea level change and concentrations of key greenhouse gases. The website quickly gained widespread recognition both within and outside NASA, with CNN.com calling it "one of the most stimulating, most thorough climate tracking sites you'll find anywhere on the Web."

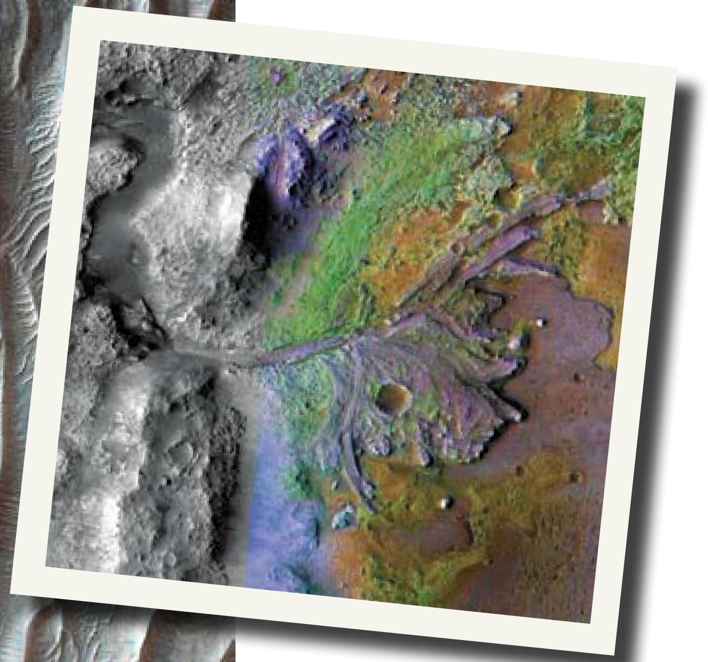
July

08

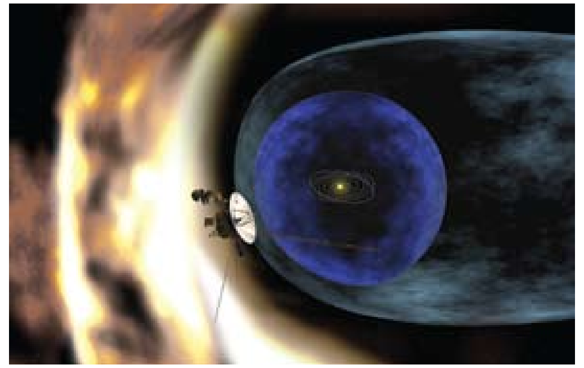
VISIONS of ANCIENT MARS

Vast lakes, flowing rivers and varied other wet environments that could have supported life were plentiful on ancient Mars, views from Mars Reconnaissance Orbiter showed. The big surprise was how pervasive and long-lasting Mars' water was, offering a rich variety of wet environments hospitable to life instead of the acidic world less conducive to life suggested by other spacecraft data in recent years. Throughout the year the orbiter delivered a rich haul of science findings, from pictures of dust devils to evidence of buried glaciers. The orbiter also spent much time helping sister spacecraft Phoenix communicate with home by relaying the lander's data to Earth. By year's end the orbiter wrapped up its two-year primary mission and set forth on an extended phase.

Delicate layers of dust shaped by wind and water in Ius Chasma in the western region of the vast canyon Valles Marineris are caught by Mars Reconnaissance Orbiter (center). Near right, an avalanche in action on the planet's north polar scarps. Far right, a delta in Jezero Crater that scientists say once held a lake.



SQUASHED ENERGY



It may be lonely on the outer edge of the solar system, but for Voyager 1 and 2 that doesn't mean it isn't fertile ground for new discoveries. In July, scientists said mission data show that the energy bubble surrounding the solar system — known as the heliosphere — is slightly squashed on one side. The bubble, formed by the wind of charged particles flowing out from the sun, ought to be evenly shaped. Scientists suspect that a magnetic field outside the solar system must be pushing it out of shape. Years after their "Grand Tour" of the outer planets Jupiter, Saturn, Uranus and Neptune, the spacecraft are continuing outward toward interstellar space, making Voyager 1 the most distant human-made object.

Quick Takes

Like Mark Twain, reports of the **Ulysses** spacecraft's demise proved to be exaggerated. NASA announced plans to terminate the mission around the first of July because declining power from the onboard nuclear source was expected to cause the spacecraft to freeze. The spacecraft outlived expectations, however, continuing to communicate with Earth past the end of 2008 — after 17 years in space, far surpassing its original mission design. Later in the year, scientists announced that data from the mission showed the sun's output of plasma — the ionized particles streaming away to form the solar wind — had fallen to a 50-year low.

> Launched in 1977, NASA's Voyager missions transformed humanity's view of the solar system. Now in their fourth decade, they are sending back information about the borderlands of interstellar space.
>
> NATURE

08 August

ON with the JOURNEY

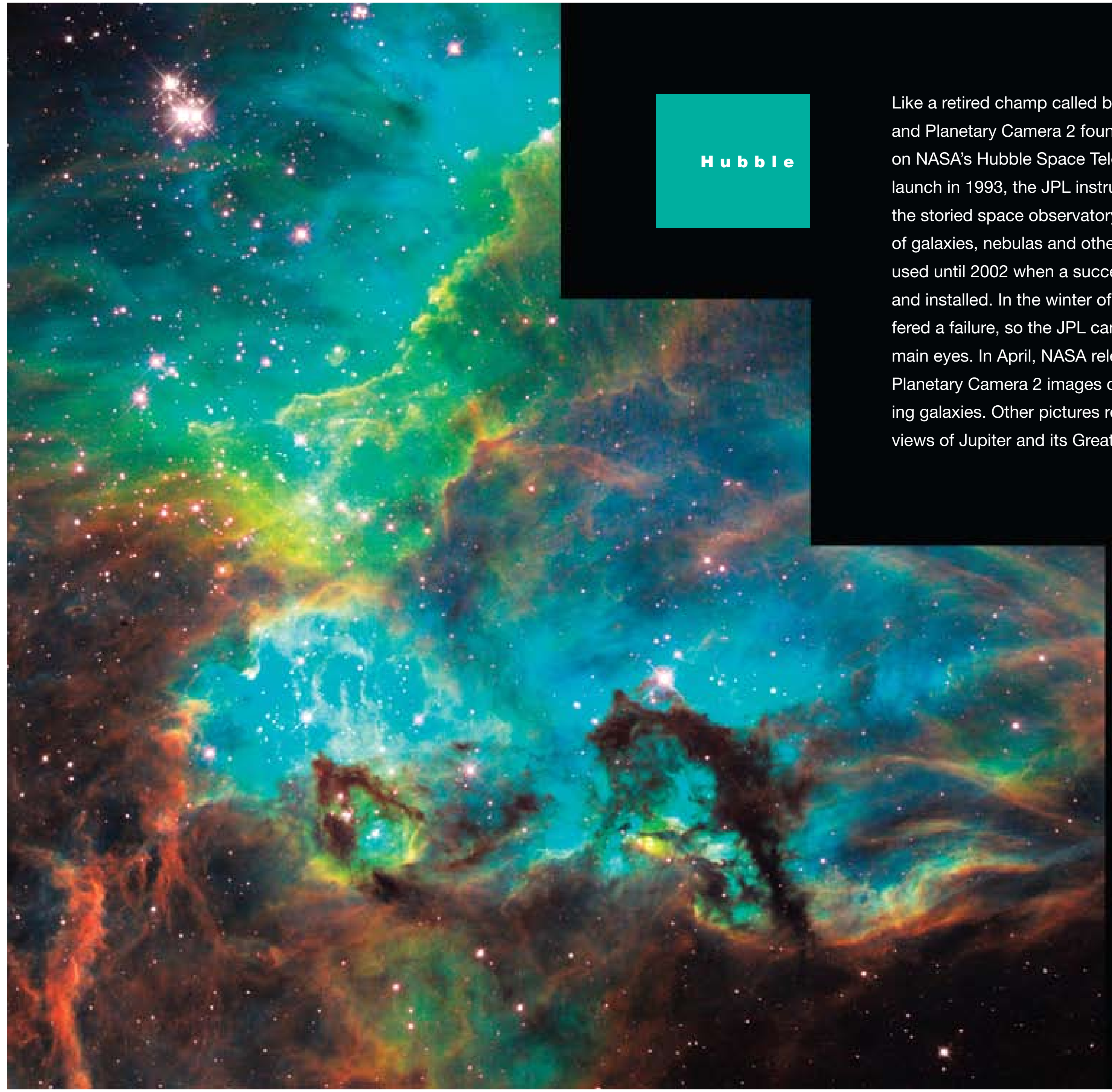
For the Mars rover Opportunity, the adventure yet to come may be all about the journey and not the destination. But given that the robotic geologist has greatly outstripped expectations up to now, who knows how far it will get? In August, Opportunity climbed out of the 800-meter-wide (half-mile-diameter) Victoria Crater and set a course for Endeavour Crater, a much larger 22-kilometer (or 14-mile) bowl that — if Opportunity succeeds in getting there — would give the robot access to deeper layers of soil than it has seen so far. The rub is that the eight miles to get to Endeavour is farther than Opportunity has traveled so far in all its time on the planet — in fact, it would be the longest overland trek ever made on another world. The rover will have plenty of opportunities to sample rocks in transit; toward the end of the year it checked out a meteorite called Santorini as it rolled toward Endeavour. Meanwhile, Opportunity's twin in the Mars Exploration Rover mission — Spirit — endured hardships as it battled to survive on the far side of the planet. Early in 2008 Spirit barely managed to move itself, with one of its six wheels inoperable, to a spot where it could sit out the harsh winter. Overtaken by a dust storm, Spirit's solar panels lost so much power that the rover stopped transmitting for a few days in October. The ground team was elated, however, when Spirit got back in touch. The year was the fifth on Mars for both rovers, which far exceeded their originally planned three-month lifetimes.

JPLer Nagin Cox enjoys 3-D pictures from the rovers.

Quick Takes

Google for satellites? It may sound far-fetched, but that's the way technologists are describing a new concept for a Web portal that would make getting data from Earth-observing satellites almost as easy as typing in an Internet search. While most of today's satellites are controlled completely separately, researchers working for NASA's **New Millennium Program** have developed a system that stitches such spacecraft together into a seamless, easy-to-use network. The effort could make it easier and quicker to obtain needed data from Earth satellites during critical events such as tropical storms — in the process, potentially saving lives.

> The Spirit and Opportunity rovers have arguably become NASA's most recognizable characters in the four years they've been reporting back from the red planet.
>
> LOS ANGELES TIMES



Hubble

Like a retired champ called back into the game, the Wide Field and Planetary Camera 2 found a new starring role in 2008 on NASA's Hubble Space Telescope. For eight years after its launch in 1993, the JPL instrument was the primary camera on the storied space observatory, delivering many iconic images of galaxies, nebulas and other cosmic sights. It was heavily used until 2002 when a successor instrument was launched and installed. In the winter of 2007–08 that successor suffered a failure, so the JPL camera again became Hubble's main eyes. In April, NASA released dramatic Wide Field and Planetary Camera 2 images of an exploding star and colliding galaxies. Other pictures released during the year included views of Jupiter and its Great Red Spot.

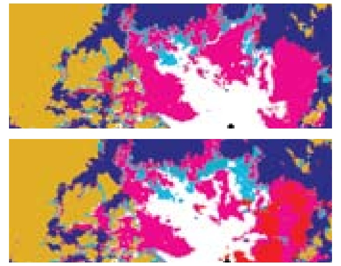
September 08

HURRICANE AFTERMATH

When residents of Galveston, Texas, returned to find their homes in ruin after Hurricane Ike made landfall in September, the joint JPL–Japanese Advanced Spaceborne Thermal Emission and Reflection Radiometer provided a perspective of how the landscape was affected. Equipped with imagers that view Earth in 14 different spectral bands, the instrument on NASA's Terra satellite showed how 7-meter-high (23-foot) waves from the storm pushed saltwater 15 kilometers (nearly 10 miles) inland. At right, before and after views of Galveston. Earlier in the year, the radiometer captured images of Chile's Chaitén Volcano, which abruptly awoke after slumbering for 9,000 years and hurled plumes of ash, sulfur and water high into the sky, where it blew hundreds of miles across Chile and Argentina.

Quick Takes

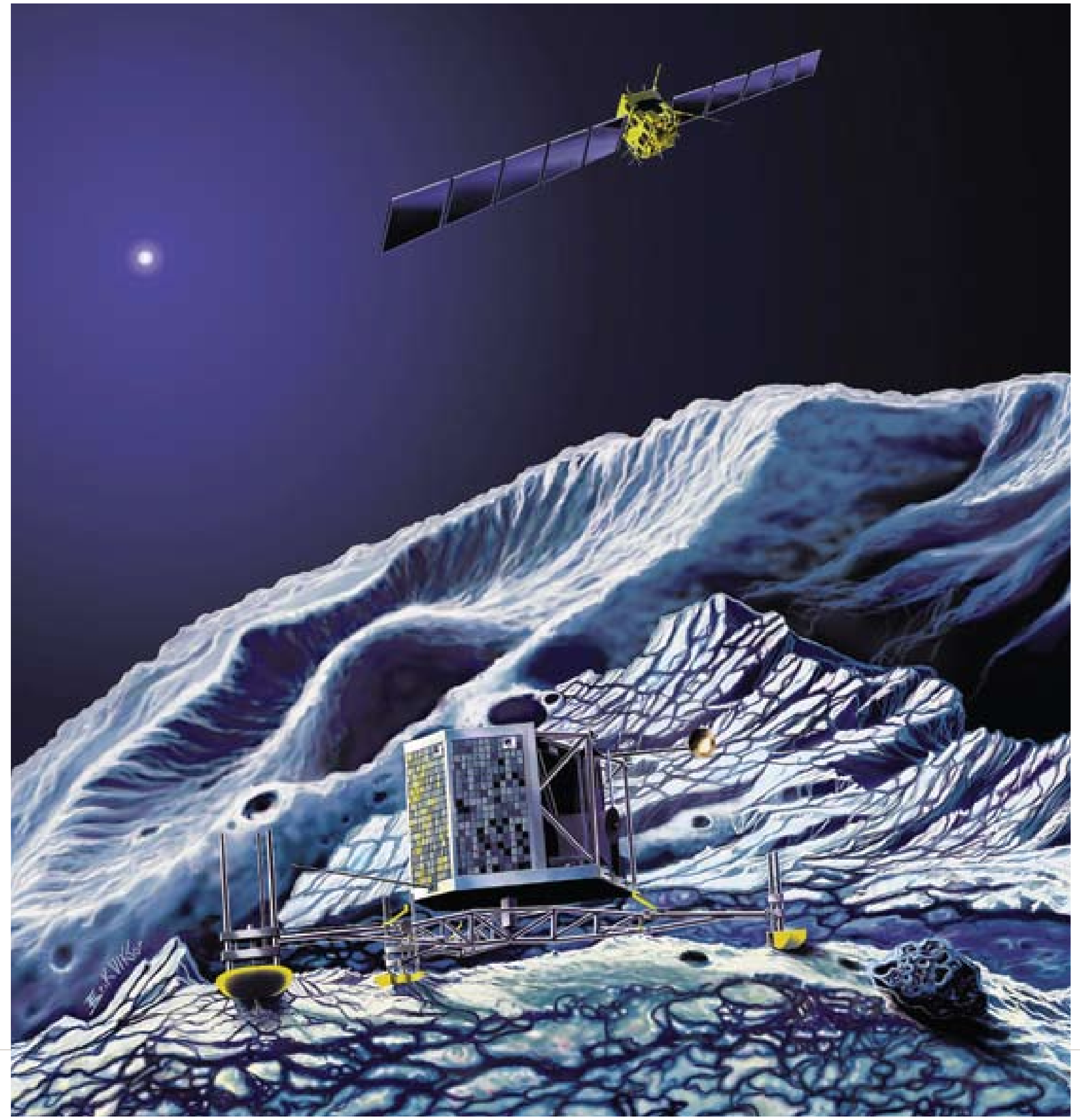
For JPL's **Quick Scatterometer** satellite, or QuikScat, answers to many questions about Earth's climate are blowing in the wind. The satellite's radar instrument can not only measure winds across the world's oceans, it can also distinguish sea ice from open water and discern different kinds of ice. In September, the satellite mapped historic changes when it detected a major melting of sea ice that cleared Arctic ocean routes. Over the summer, the satellite chronicled the arrival and impact of the tropical storms Dolly, Fay and Hanna. Also during 2008, seven years of QuikScat data were used to create new atlases of ocean wind patterns around the globe.



ROADSIDE ATTRACTIONS

Well into a 10-year-long sojourn to a comet, the Rosetta mission team might understandably ask, "Are we there yet?" But patience was rewarded with a fascinating side trip to an asteroid along the way. The European Space Agency mission, carrying JPL's Microwave Instrument for the Rosetta Orbiter, was enlivened by a flyby of an asteroid called 2867 Steins. Next up is an Earth flyby in 2009 and a pass by another asteroid in 2011 before arriving to orbit and set a lander on 67P/Churyumov-Gerasimenko in 2014. Fixed to the orbiting portion of the spacecraft, the JPL instrument will be activated to study the properties of the comet nucleus surface, yielding new information on how comets form, what they are made of and how they change over time.

Artists' concepts of the Rosetta spacecraft arriving at its target comet (below), where it will deploy a lander (right).

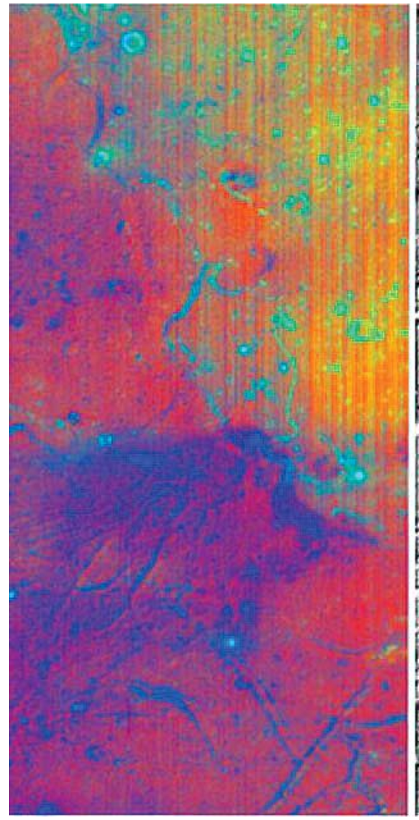


October 08

LUNAR PROSPECTING

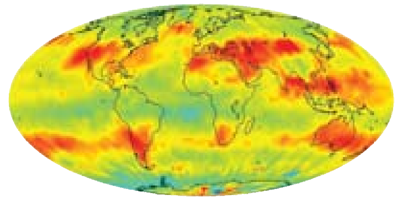
Is there gold in those hills? Or, for that matter, iron or pyroxene? JPL's Moon Mineralogy Mapper wants to find out. The instrument took to flight October 21 on the first spacecraft bound for the moon sent by India, Chandrayaan 1. Entering orbit in November, the instrument sent back three-dimensional views of the moon's Orientale Basin before year's end. While substantial deposits of gold are unlikely, the instrument detected iron-bearing minerals.

The Orientale Basin region on Earth's moon is revealed at different wavelengths in a composite image taken by the Moon Mineralogy Mapper instrument.

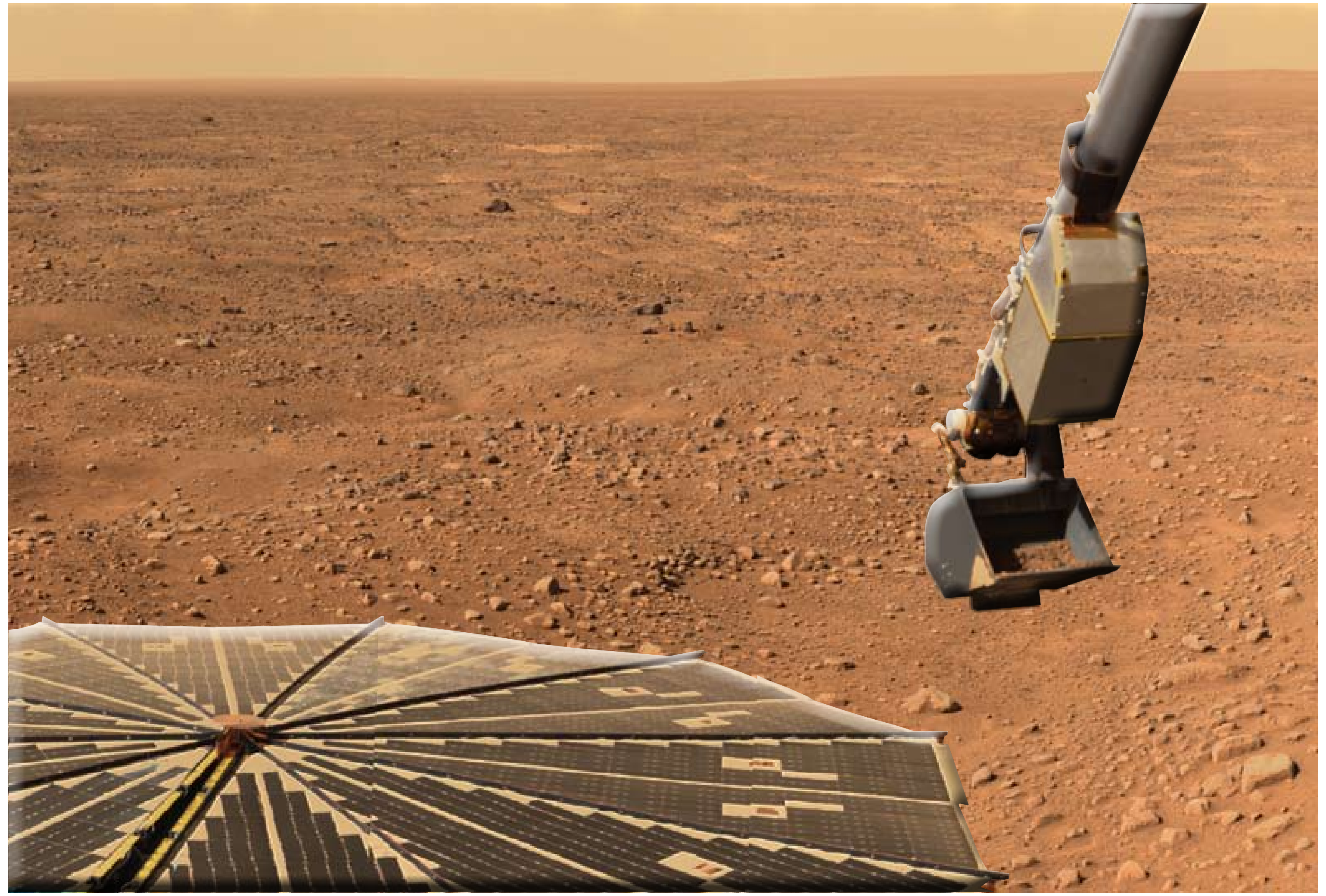


Quick Takes

New views of how the key greenhouse gas carbon dioxide moves around the planet were offered by JPL's **Atmospheric Infrared Sounder** instrument on the NASA Aqua satellite. The maps chart carbon dioxide in Earth's mid-troposphere, an area about 8 kilometers, or 5 miles, above the surface. Earlier in the year, the JPL instrument captured infrared views of Tropical Storm Dolly in the Gulf of Mexico. Right, concentrations of carbon dioxide transported around Earth are charted by the Atmospheric Infrared Sounder.



November 08



They knew all along that the end was inevitable, but when it came — it was still hard. Tens of thousands of public fans who followed Twitter.com dispatches from the Mars Phoenix lander — actually ghostwritten for the spacecraft by JPL — joined together in a virtual wake when the lander fell silent after operating in the Martian arctic for more than five months. As planned from the start, decreasing sunlight with the onset of Martian winter meant that in time there was not enough solar energy to power Phoenix's instruments, and the spacecraft radioed its last dispatch November 2. Wired.com held a contest to pen epitaphs for the lander. The winner: Veni, vidi, fodi ("I came, I saw, I dug").

R.I.P. PHOENIX

The Phoenix lander's iconic portrait of its robotic arm and solar panel against the background of its landing site in the Martian arctic.

WHISPER JET

Gliding across the solar system, pushed forward by an engine with a thrust gentler than the softest whisper? That's the flight plan for the Dawn mission to the asteroid belt, which is exploiting the once-futuristic technology of ion propulsion. As wispy as the engine's output is, it will enable the spacecraft to achieve a first in space — orbiting one target body in the solar system and then a second. In Dawn's case, its destinations are the large asteroid Vesta and the dwarf planet Ceres, where it will seek clues to early conditions in the solar system. In October it wrapped up a 10-1/2-month round of ion thrusting and began coasting toward Mars, which it will swing by in early 2009 en route to its 2011 arrival at Vesta.

Quick Takes

Having a guest in the house with a sensitive nose can be awkward, but for the residents of the International Space Station it's a boon — and could save a life. When space shuttle Endeavour visited the orbiting outpost in November, it carried aloft **E-Nose**, a JPL instrument designed to be a "first responder" that can sense dangerous substances in the air astronauts breathe — for example, ammonia, mercury, methanol or formaldehyde. If a six-month stint on the space station proves successful, the shoebox-sized instrument might be used in future missions as part of an automated system to let astronauts breathe easier.

December 08

NEXT UP on MARS

JPL's next-generation rover, Mars Science Laboratory, took shape during the year as engineers and technicians largely finished putting together the large rover itself and its cruise and descent stages. By year's end, however, JPL and NASA concluded that it was too risky to continue to press ahead toward a launch in the fall of 2009; among other issues, they were waiting on delivery of space-qualified motors and gearboxes. Liftoff was reset for the next Mars launch window in 2011, allowing the team to drop back from double and triple shifts to a more measured pace as the spacecraft is completed and tested. Three times as heavy and twice as wide as the rovers currently on Mars, the Science Lab will carry more advanced instruments than any mission ever sent there, analyzing soil and rock samples to see if the landing region's past environment was favorable for life and for preserving evidence of life.

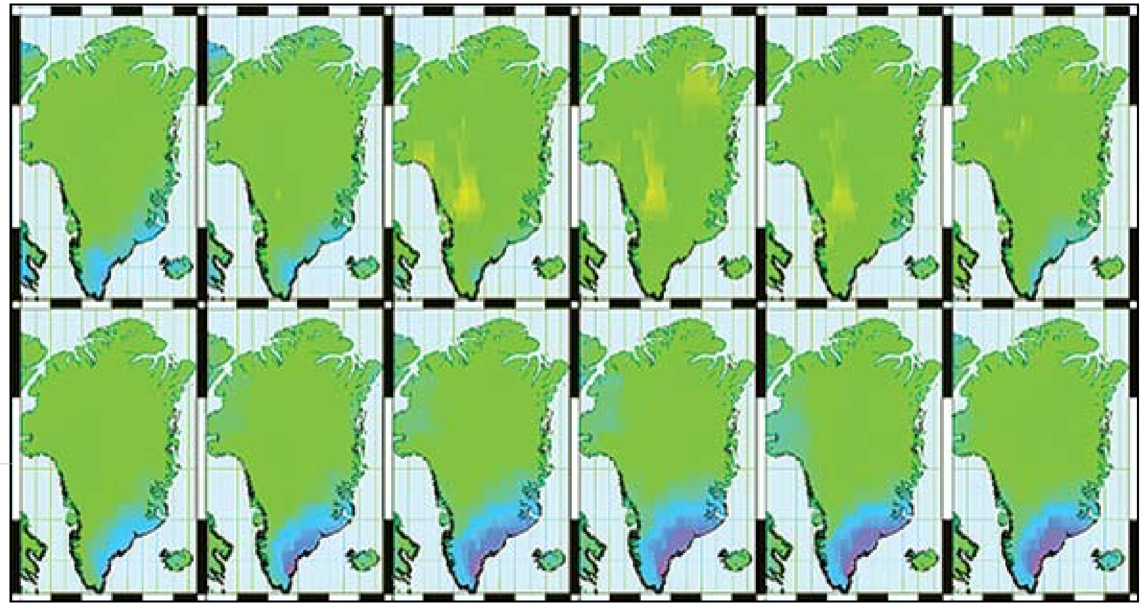
Mobility engineer Sean Haggart (right) tests a wheel for Mars Science Laboratory.

Quick Takes

Just catching some rays? That's the whole idea for the **Active Cavity Radiometer Irradiance Monitor Satellite**, or AcrimSat, which marked its 10th year in orbit. The satellite's mission is to take a precise measure of how much energy from the sun reaches Earth, impacting our winds, land and oceans. Some fluctuations have been surprising. A few years ago, the satellite found a drastic drop in energy reaching us when the planet Venus passed in front of the sun from Earth's point of view for several hours. The decrease was equivalent to all the energy used by humans in an entire year.

MULTIPLE TALENTS

Here's to multitasking. After the Deep Impact spacecraft completed its dramatic mission firing a penetrator into the nucleus of comet Tempel 1 in 2005, scientists and engineers realized that it could go on to accomplish not just one extended mission but two. The team set a course for another comet, Hartley 2, which the spacecraft will fly by in late 2010. But scientists realized they could also use the spacecraft for an entirely different quest. For eight months in 2008, Deep Impact trained its camera on more than a half dozen stars known to possess planets, and watched as the planets passed in front of each star. Measuring the light of these stars from space avoided "noise" that astronomers encounter when they try such studies from the ground. In December Deep Impact made a pass by Earth, sending it on the next leg of its journey.



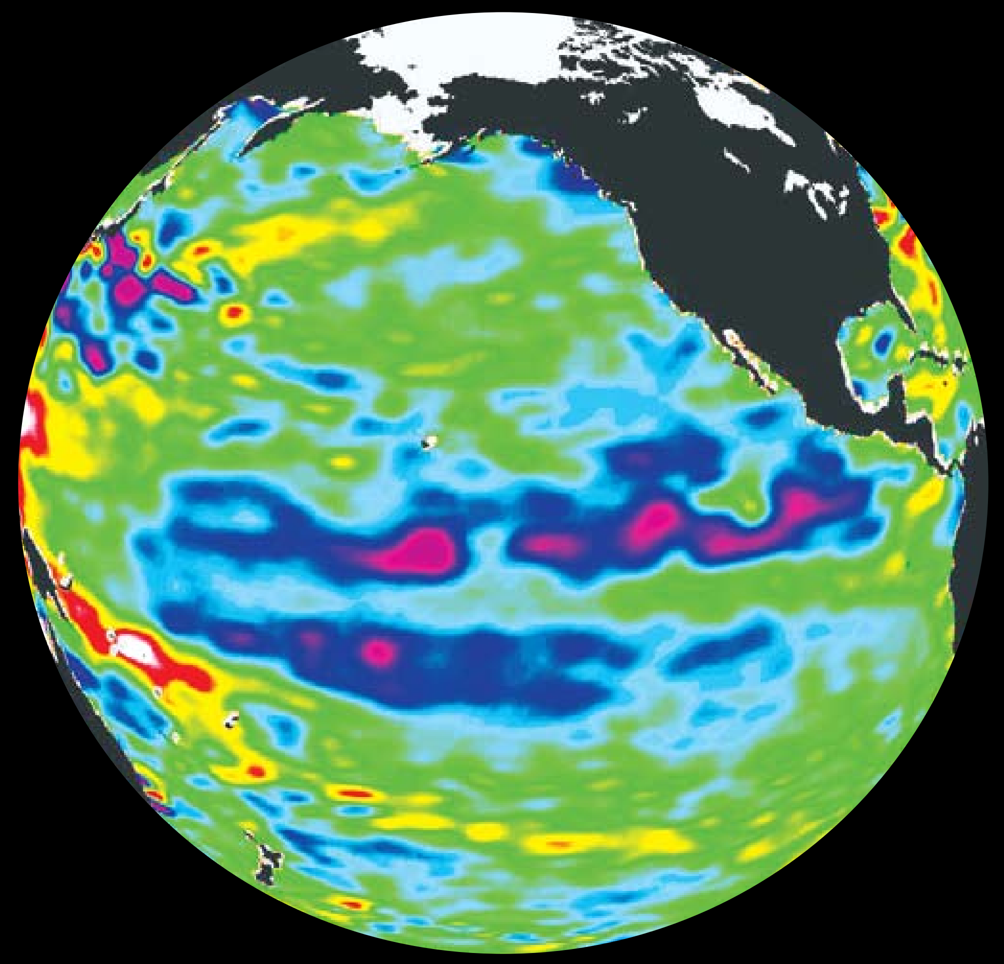
The VANISHING ICE

More than 2 trillion tons of land ice in Greenland, Antarctica and Alaska have melted since 2003, according to findings from the Gravity Recovery and Climate Experiment, or Grace, mission, a collaboration between JPL and the German Space Agency. More than half of the loss of landlocked ice in the past five years has occurred in Greenland; the water melting from Greenland alone during that time would fill up about 11 Chesapeake Bays. Scientists also used the twin Grace satellites to put a number to the melting of mountain glaciers in the Gulf of Alaska. The satellites show how ice mass changes through its effect on Earth's gravity field.

Ice loss in Greenland is documented over time by the Grace satellites. Areas of greatest loss appear in blue and purple.

Rise and Fall

Temperatures of the world's seas are gradually climbing, but that doesn't mean they don't go up and down on shorter time scales. Nowhere is that truer than in the planet's largest ocean, the Pacific, where temperatures rise and fall every five to twenty years as part of what's called the Pacific Decadal Oscillation. In December, the Jason 1 satellite revealed the Pacific was locked in a strong, cool phase of the long-term pattern, with no sign of the El Niño and La Niña trends that raise or lower ocean temperatures, respectively. Jason 1, a collaboration between JPL and the French Space Agency, marked its 30,000th orbit of Earth since its 2001 launch. Left, in 2008 Jason 1 data showed that one of the strongest La Niña events in many years was slowly weakening but continued to blanket the Pacific Ocean near the equator.



08 Major External Awards

Shari Asplund
Award of Distinction,
International Academy of the Visual Arts

CloudSat Mission Team
Stellar Award,
Rotary Club of Houston

Brad Dalton
Cooperative Conservation Award,
U. S. Department of the Interior

Charles Elachi
Goddard Award,
American Institute of Aeronautics and Astronautics

Leigh Fletcher
Keith Runcorn Prize,
Royal Astronomical Society

Lee-Lueng Fu
Elected Member,
National Academy of Engineering

Jon Giorgini
Harold Masursky Award,
Division for Planetary Sciences,
American Astronomical Society

Jairus Hihn
Lifetime Achievement Award,
USC Center for Systems and Software Engineering

Fred Hadaegh
Elected Fellow,
Institute of Electrical and Electronics Engineers

Jet Propulsion Laboratory
Foundation Award for Excellence,
American Institute of Aeronautics and Astronautics

Dwight Eisenhower Award for Excellence, U. S. Small Business Administration

Joint Non-Kinetic Effects Model and Corps Battle Simulation Development Teams
Modeling and Simulation Award,
U. S. Army

W. Timothy Liu
Elected Fellow,
American Association for the Advancement of Science

Veronica McGregor
Gold Prize, Blog Campaign
Mercury Communication Awards

Shorty Award
Sawhorse Media

Twitter.com Best Breaking News Tweet, Most Informative Tweet, Smartest Tweet, iFractal LLC

Phoenix Lander Mission Team
Astronautics Engineer Award,
National Space Club

Quick Scatterometer Mission Team
William T. Pecora Award,
U. S. Department of the Interior

Christophe Sotin
Runcorn Florensky Medal,
European Geosciences Union

Stardust Mission Team
National Air and Space Museum Trophy,
National Air and Space Museum

Ulysses Mission Operations Team
Award for Outstanding Achievement,
International Committee on Technical Interchange for Space Mission Operations and Ground Data Systems

Robert Wilson
Distinguished Service Medal,
International Committee on Technical Interchange for Space Mission Operations and Ground Data Systems

Simon Yueh
Elected Fellow,
Institute of Electrical and Electronics Engineers

> Whoever thought a NASA spacecraft could be so adept at social networking and Web 2.0? For users of Twitter, a Web microblogging service, the Phoenix Mars lander has been sending pithy news "tweets" to the cell phones and computers of interested "followers."
>
> NEW YORK TIMES

08 Partners

MAJOR CONTRACTOR

Lockheed Martin Corporation
GRAIL, Juno, Mars Science Laboratory, Mars Odyssey, Mars Phoenix Lander, Mars Reconnaissance Orbiter, Rosetta, Spitzer Space Telescope, Stardust

ITT Corporation
Deep Space Network Operations

Ball Aerospace & Technologies Corporation
CloudSat, Deep Impact, Kepler, Wide-field Infrared Survey Explorer

Computer Sciences Corporation
Information Technology Infrastructure Support

Northrop Grumman Space & Mission Systems Corporation
James Webb Space Telescope Mid-Infrared Instrument, Space Interferometry Mission

Lockheed Martin Integrated Systems
Desktop Institutional Computing

Raytheon
Data Systems Implementation and Operations

Orbital Sciences Corporation
AcrimSat, Dawn, Jason, Orbiting Carbon Observatory, Space Technology 8

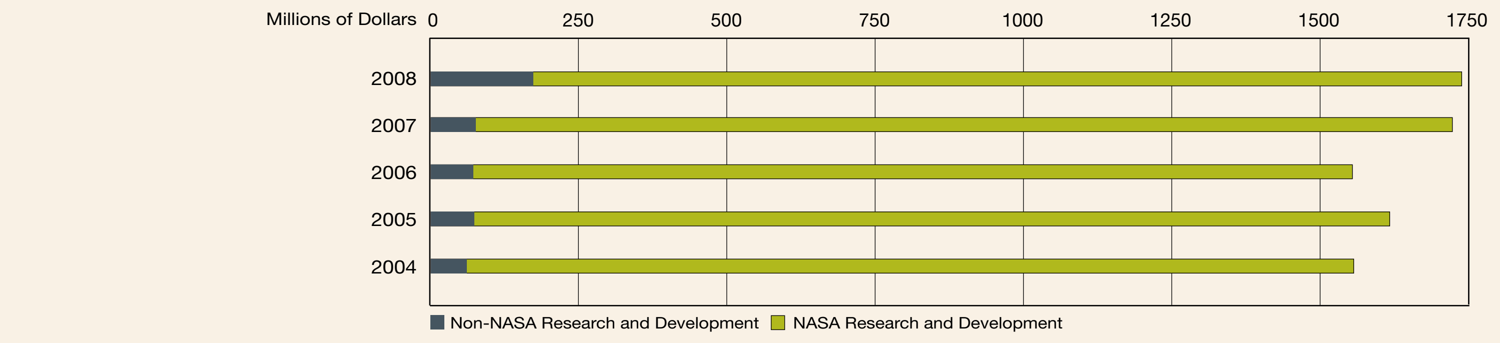
Utah State University Research Foundation
Wide-field Infrared Survey Explorer

Swinerton Builders
Construction of Flight Project Center Building

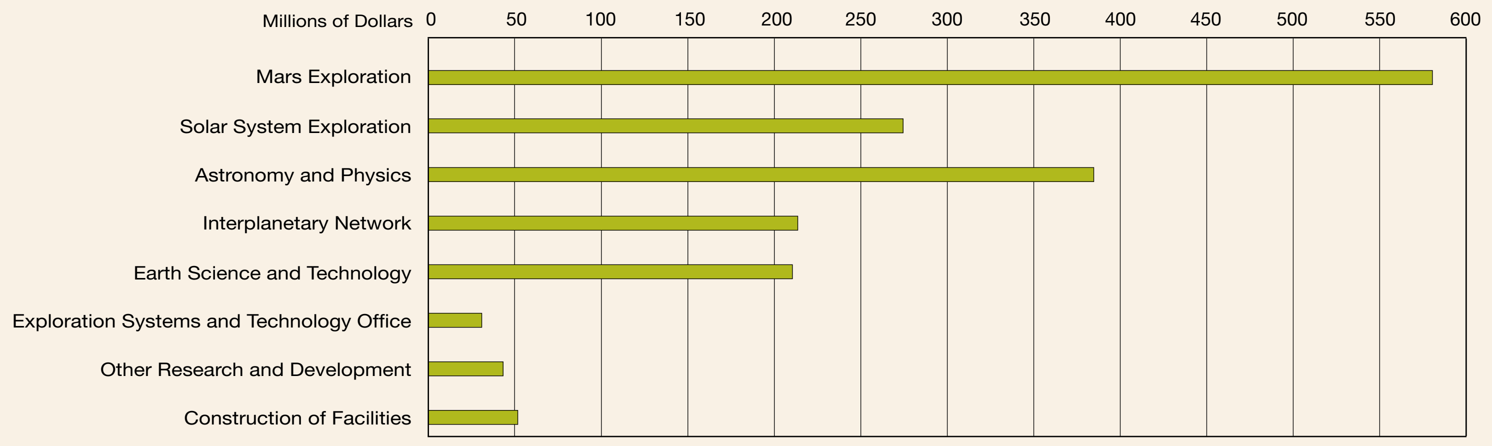
08 Charts

BUDGET / WORKFORCE

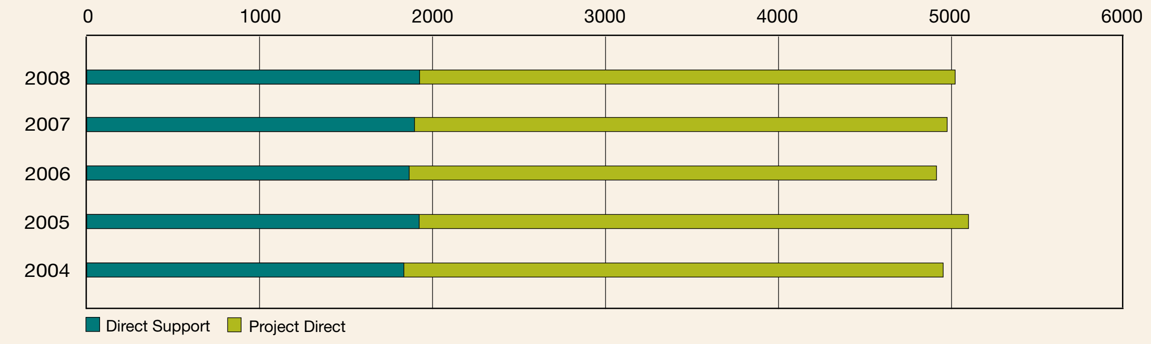
Total Costs



Total Costs by Program



Total Personnel



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