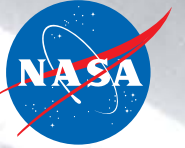


National Aeronautics and
Space Administration



Dare Mighty Things

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Jet Propulsion Laboratory
ANNUAL REPORT





Cover: One of the first views from Mars Curiosity shortly after landing, captured by a fish-eye lens on one of the rover's front hazard-avoidance cameras.

Inside Cover: The team in mission control erupts in joy when Curiosity's first picture reaches Earth.

This page: Tiny moon Tethys (upper left) dwarfed by Saturn and its rings, as captured by the Cassini spacecraft.

Far page: A colorful bow shock in dust clouds surrounding the giant star Zeta Ophiuchi, imaged by the Spitzer Space Telescope.



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Charles Elachi

Director, Jet Propulsion Laboratory

Can it get any better than this? That would have been an excellent question to ask me the night of August 5, 2012. And I know what my answer would have been: It's hard to imagine how.

Of course, the defining moment for JPL in 2012 was the amazing landing of Mars Science Laboratory's Curiosity rover that Sunday evening. After all the hard work of design and fabrication and testing, and redesign as the launch slipped by two years, there was nothing to compare to standing in mission control on the arrival evening and watching as the spacecraft executed its incredibly complex landing sequence that ended with the rover safe on the Red Planet's surface. A century ago, President Teddy Roosevelt told the world to "Dare mighty things," and with Mars Curiosity, we did.

As singular an experience as Curiosity's landing was, there was so much more to the year of which we can be equally proud. Dawn headed for the history books as it became the first spacecraft ever to orbit one target body and then depart to orbit another, visiting the two most massive objects in the asteroid belt — Vesta and Ceres. The Gravity Recovery and Interior Laboratory, or GRAIL, mission at Earth's moon came to a literally smashing end as its twin spacecraft capped their highly successful orbital tour with a dive into the side of a lunar mountain. The long-lived Cassini continued to uncover new science at Saturn, while Juno trimmed its sails as it progressed toward Jupiter.

A century ago, President Teddy Roosevelt told the world to "Dare mighty things," and with Mars Curiosity, we did.

JPL's Earth science missions proved more than ever how vital they are to monitoring and understanding our home planet — providing important data on climate change and storm tracking.

I was very excited to see four new Earth science missions progress in development as our next group of launches, due to be sent into space in 2014 and 2015.

2012 saw a new space-based telescope — the Nuclear Spectroscopic Telescope Array, or NuSTAR — join our fleet of off-world observatories scrutinizing the universe across the energy spectrum. These promise science returns ranging from studies of black holes to the quest for Earth-like planets around other stars, and even findings that can help us understand the mystery of dark energy.

Throughout the year, the Deep Space Network made progress on modernizing its stable of antenna dishes on three continents, and we embarked on important technology initiatives to enable missions of the future. JPL's reimbursable program focused on strategic technology thrust areas in advanced imagery, information and data science, robotics and autonomy, and energy. Coupled with potential space and airborne flight missions with our federal and commercial partners, the laboratory is well positioned to help solve problems of national significance.

All of us at JPL were very excited to see NASA approve not one but two future Mars missions — a competitively selected lander, InSight, that will study the planet's interior in 2016, and a major new rover in 2020.

All of these efforts make me exceptionally proud to be at JPL, and the part we play both as a member of the NASA family and a division of the California Institute of Technology. The successes of 2012 were truly examples of the genius and perseverance of our 5,000 employees, some of whom you'll meet in the pages that follow. They represent the passion and skill of the laboratory as a whole, and I hope you enjoy their stories.

Exploring Month by Month

JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
<p>Kepler discovers three smallest exoplanets</p> <p>Jason 1 and 2 see La Niña peaking</p>	<p>Mars Odyssey thermal camera logs 10 years of discoveries</p>	<p>Wise releases all-sky atlas</p>	<p>Mars Reconnaissance Orbiter detects changes in sand dunes</p>	<p>Spitzer Space Telescope detects light of alien "super-Earth"</p> <p>Opportunity rover rolls after fifth Martian winter</p> <p>Galaxy Evolution Explorer images black hole shredding a star</p>	<p>NuSTAR launches</p>	<p>Mars Curiosity lands</p>	<p>Dawn departs from Vesta</p>	<p>Aquarius joins special campaign to study ocean surface salinity</p>	<p>Deep Impact tweaks flight path for possible asteroid encounter</p> <p>AIRS, CloudSat track Hurricane Sandy</p>	<p>Herschel finds cometary belts at other stars</p> <p>Goldstone radar images asteroid 2007 PA8</p> <p>Planck detects bridge of hot gas between galaxies</p>	<p>Voyager enters new realm</p> <p>GRAIL craft end mission, impact moon</p>

As events go, this was one that lived up to its name. For Mars Science Laboratory's Curiosity rover, the "Seven Minutes of Terror" began as the spacecraft screamed into the Red Planet's atmosphere at 13,000 miles per hour, setting off a wild descent with 76 explosive bolts firing to set off a furious schedule of events, finally culminating as the car-sized rover was lowered via cables from a jet-powered platform onto the planet's surface.



On the Trail of Possible Life.

Mars explorers (from left) Dara Sabahi, Tomas Martin-Mur, Leslie Tamppari, Allen Chen, Magdy Bareh, Joy Crisp, Keith Comeaux, Jeff Plaut.



To the joy of everyone watching around the world, and especially those gathered in JPL's mission control, the landing on August 5 was a flawless success. The most complex landing sequence ever designed clocked out impeccably, setting the one-ton rover near the foot of a three-mile-tall mountain inside Gale Crater near Mars' equator. Scientists expect Mount Sharp's terraces to reveal the planet's history like the chapters of a history book, helping them determine if the region was ever hospitable to microbial life.

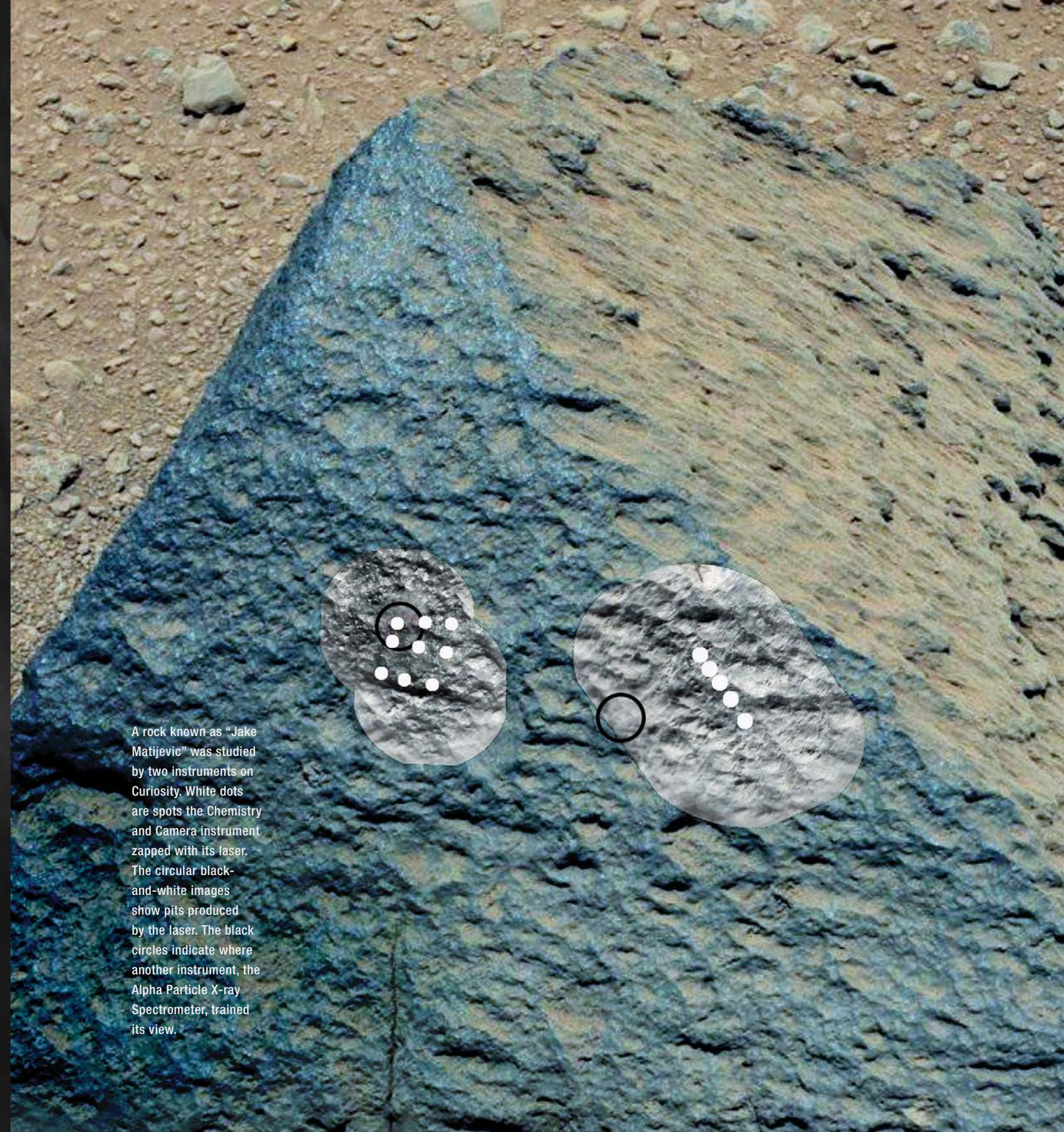
Before setting off for Mount Sharp, Curiosity took its time surveying the locale around the landing site during the remainder of 2012, finding surprisingly rich geology. Scientists were excited in September when Curiosity ran across a riverbed showing clear signs that a stream once ran there vigorously — the first evidence of its kind for past flowing water. In October, Curiosity's Chemistry and Mineralogy instrument sampled soil for the first time, revealing minerals similar to volcanic rocks in Hawaii. Another Curiosity experiment, the Sample Analysis at Mars instrument, inspected the atmosphere, offering clues about how the planet lost the gases that originally surrounded it. A football-sized rock scrutinized by two instruments showed its composition to be unexpectedly diverse — strikingly more so than rocks seen by previous rovers.

Am I an engineer, or a scientist?

I guess it depends on the day you ask me. I consider myself a scientist, but I love developing instruments to fly on space missions. As an undergraduate at Cornell I was lucky enough to get a job on the Mars Exploration Rovers, and that eventually led to coming to JPL and working on the ChemCam instrument for Mars Science Laboratory. How many people have a job where they send commands to a rover on Mars telling it to fire lasers and take pictures? Curiosity's landing of course was a wonderful experience, but the high point for me came a couple of weeks later when the ChemCam instrument took science data for the first time, firing its laser at a rock and then getting the spectra to show what the rock is made of. It was a great feeling, walking into the room with the science team and everyone so excited about the results and knowing I played my little part in making that happen. Seeing that joy was like seeing your child's face on Christmas when you gave them exactly what they wanted.

Lauren DeFlores

Lead Instrument Engineer, ChemCam



A rock known as "Jake Matijevic" was studied by two instruments on Curiosity. White dots are spots the Chemistry and Camera instrument zapped with its laser. The circular black-and-white images show pits produced by the laser. The black circles indicate where another instrument, the Alpha Particle X-ray Spectrometer, trained its view.

Elsewhere on Mars, the Opportunity rover, Curiosity's older and smaller sibling that has ranged across the planet since 2004, ran across puzzling BB-sized spheres at one outcrop unlike anything previously seen. Along the edge of Endeavour Crater, Opportunity examined rocks that imaging by orbiters suggested could contain clay minerals that form under conditions possibly favorable to life.

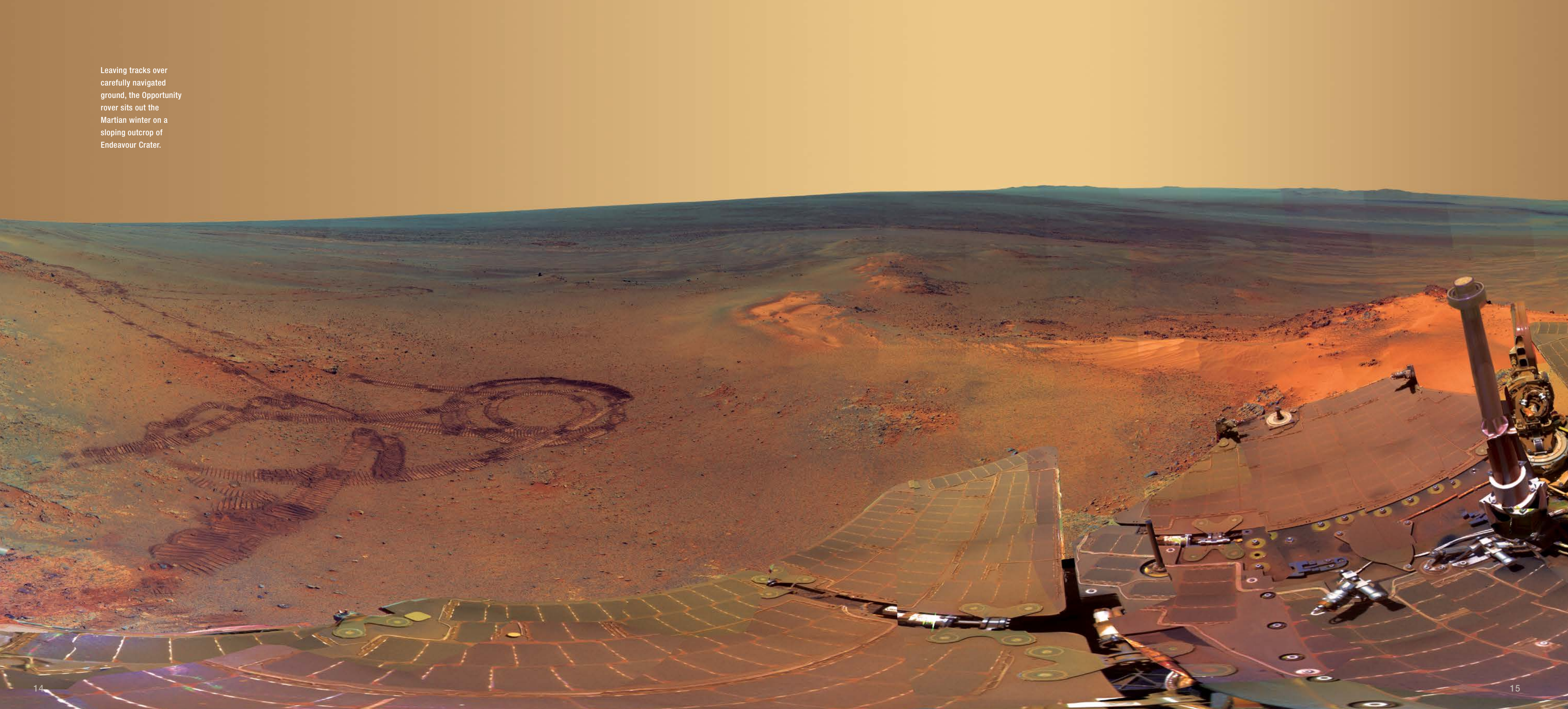
Overhead, the Odyssey orbiter continued to set records as the longest-serving spacecraft ever sent to Mars. It has now circled the planet more than 50,000 times over nearly 12 years. Mars Reconnaissance Orbiter, on station above the planet since 2006, continued to discover changes in the planet, adding to the understanding of processes active there today. Among them were carbon dioxide snow falling on the winter polar ice cap, unexpectedly large changes in sand dunes, and a whirlwind caught in action lofting a column of dust some 12 miles high.

To cap an historic year on Mars, NASA announced that JPL will undertake two future missions to the Red Planet. In August, JPL's InSight mission was competitively selected to fly to Mars in 2016 where it will drill beneath the surface and study the deep interior to better understand Mars' evolution as a rocky planet. Later in the year, NASA announced approval of a major rover mission in 2020 to conduct science and pave the way for eventual human exploration. Its design will be largely based on the Curiosity rover.



A Martian dust devil roughly 12 miles high is captured winding its way along the Amazonis Planitia region of northern Mars in March 2012 by the high-resolution camera on Mars Reconnaissance Orbiter. Despite its height, the plume is little more than three-quarters of a football field wide.

Leaving tracks over
carefully navigated
ground, the Opportunity
rover sits out the
Martian winter on a
sloping outcrop of
Endeavour Crater.



From giant planets to wayfaring rocks, the varied environments of the solar system provided ample hunting ground for discovery as JPL's fleet of robotic spacecraft carried on with missions to the planets and other destinations.

Planets, Moons, Habitats.

Solar system team members (from left) Bob Mase, Christophe Sotin, John Baker, Keyur Patel, Carol Raymond, Firouz Naderi, Sabrina Feldman, Kevin Hand, Tom Hoffman, Earl Maize.



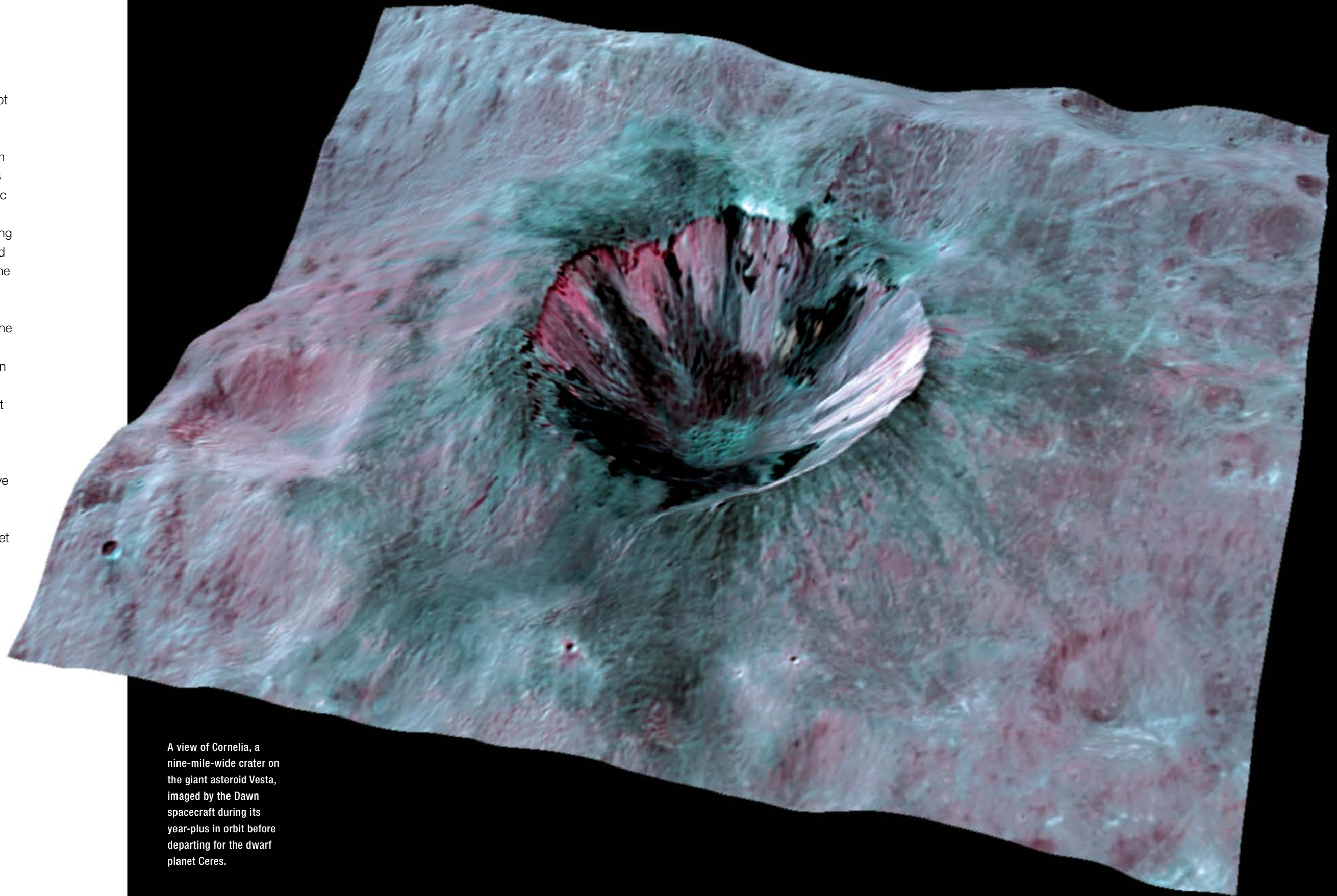
Wrapping up more than a year in orbit at the giant asteroid Vesta, the Dawn spacecraft activated its ion engines and gracefully spiralled onto a new flight path that will deliver it in 2015 to the icy dwarf planet Ceres. The innovative propulsion technology will enable Dawn to become the first spacecraft ever to orbit one target body and then another — in this case, the two most massive objects in the asteroid belt between Mars and Jupiter. As Dawn departed in September, scientists considered the trove of data it delivered during its 14 months at Vesta. Their main conclusion? The building blocks that created the rocky inner planets, Dawn revealed, were far more varied and complex than predicted by standard models of how planets in our solar system formed.

A more brash finale was in store for the twin craft orbiting Earth's moon under the Gravity Recovery and Interior Laboratory, or GRAIL, mission. After circling the moon for nearly a year, the spacecraft intentionally dipped toward the lunar surface in December, hitting a mountain near the moon's north pole. The impact site was named in honor of late astronaut Sally Ride, a member of the GRAIL mission team and former Caltech trustee. The colorful gravity maps of the moon created from GRAIL data will help scientists understand how the moon formed.

Titan, the largest moon of Saturn, had not run out of surprises for scientists on the Cassini mission after eight years in orbit around the stately ringed planet. A shift in sunlight due to Titan's changing seasons led to a wholesale reversal in atmospheric circulation on the haze-shrouded moon, unlike anything previously seen on the long mission. In Titan's "tropics," Cassini spied lakes of liquid methane, one about half the size of Utah's Great Salt Lake.

A year after its launch targeting Jupiter, the solar system's largest planet, JPL's Juno spacecraft fired its engine several times in 2012 to fine-tune its path, and took pictures of the stars in the Big Dipper to test its camera. Juno will fly by Earth in 2013 on its way to Jupiter arrival in 2016.

The team responsible for JPL's microwave instrument aboard the European Space Agency's Rosetta spacecraft began to look ahead to its 2014 arrival at the comet 67P/Churyumov-Gerasimenko. The JPL instrument will study volatile substances like water, ammonia and carbon dioxide via the microwave emissions they give off.



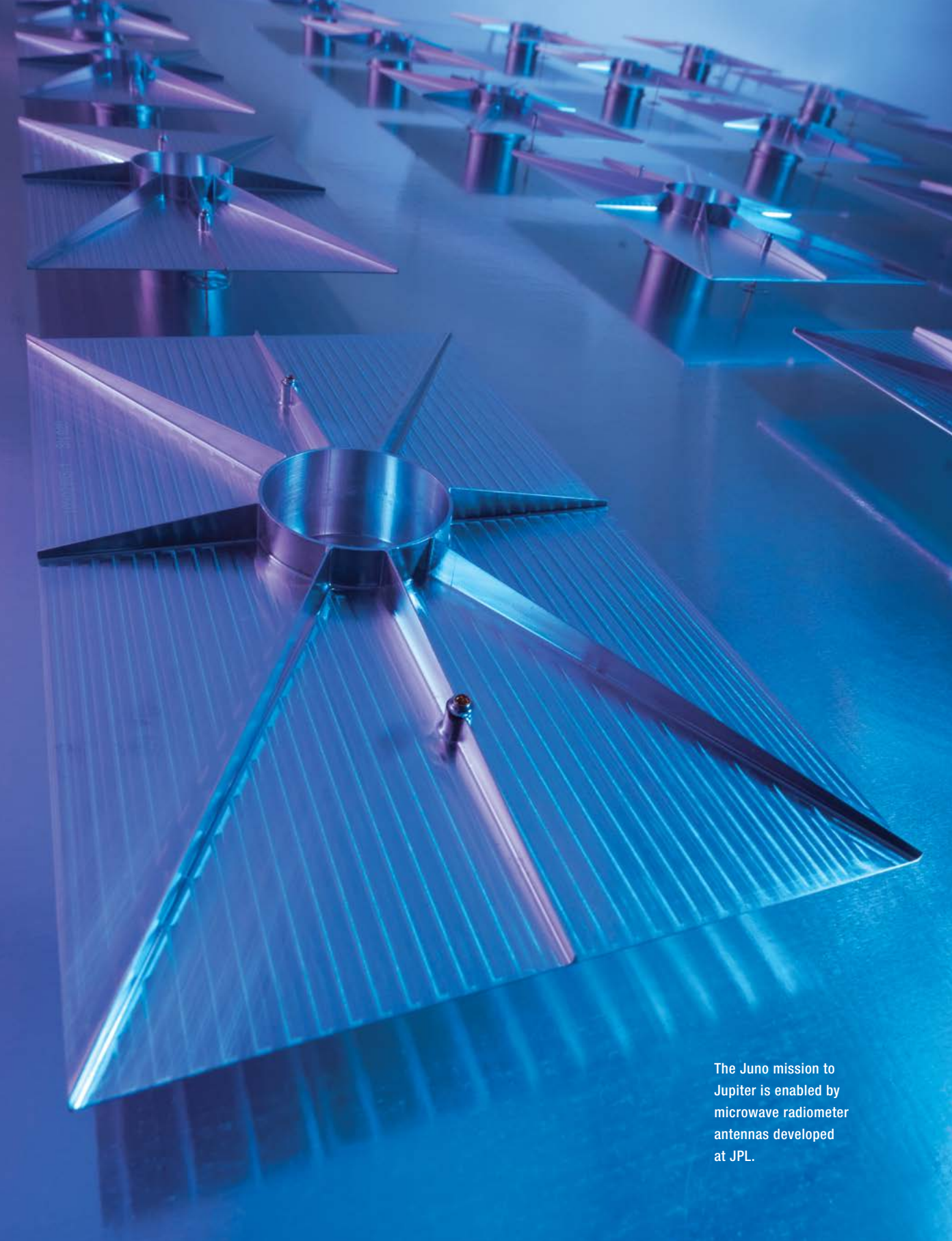
A view of Cornelia, a nine-mile-wide crater on the giant asteroid Vesta, imaged by the Dawn spacecraft during its year-plus in orbit before departing for the dwarf planet Ceres.

One of my jobs is to chair the risk

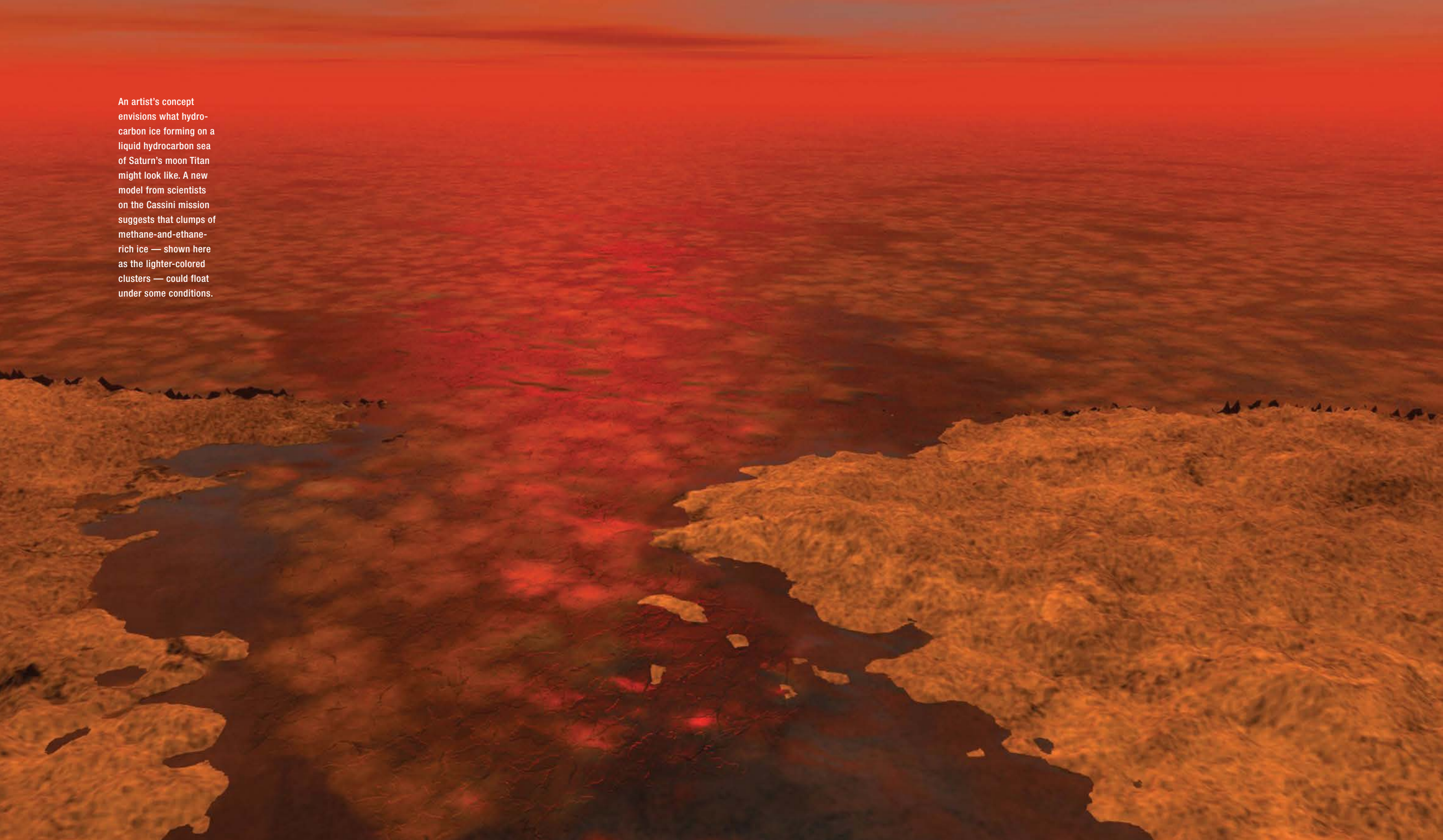
reviews before critical events on all the planetary missions. This puts me in close touch with teams all across JPL, and I get to know the missions very well. The Mars Curiosity landing was very touching to me because of what it meant to all the people involved who have been my friends and colleagues for years. This was a very challenging mission, with a delay for two years at one point due to hardware issues that was a very difficult experience for a lot of people. So the successful landing was a wonderful redemption for everyone after everything they had gone through. It was a great tribute to their dedication and determination. The success on Mars in 2012 reminded me of an amazing Fourth of July in 2005 when, against seemingly insurmountable odds, another JPL spacecraft smashed into a comet after another development process that was fraught with difficulty. To me, those two missions epitomize the very best of JPL, the ability to recover from peril and find success in the end.

Gentry Lee

Chief Engineer, Solar System Exploration



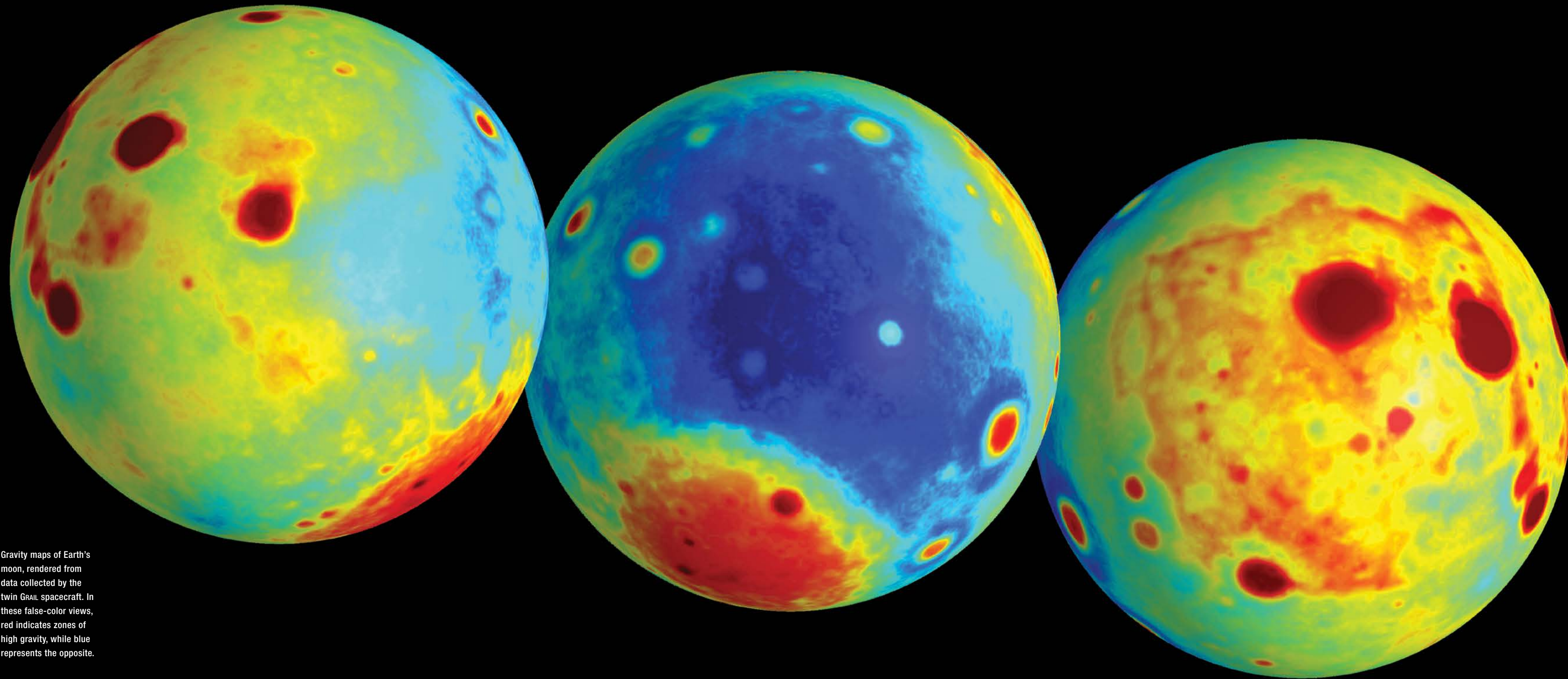
The Juno mission to Jupiter is enabled by microwave radiometer antennas developed at JPL.



An artist's concept envisions what hydrocarbon ice forming on a liquid hydrocarbon sea of Saturn's moon Titan might look like. A new model from scientists on the Cassini mission suggests that clumps of methane-and-ethane-rich ice — shown here as the lighter-colored clusters — could float under some conditions.

In October 2012, the Deep Impact spacecraft fired its engines to tweak its flight path taking it toward a possible flyby of an asteroid in 2020. The encounter will be the third major milestone for Deep Impact, which made history in 2005 when it fired a penetrator at the nucleus of a comet in 2005. Two years ago it conducted a flyby of yet another comet. Closer to home, throughout 2012 JPL's Diviner instrument continued to monitor the temperature of Earth's moon aboard NASA's Lunar Reconnaissance Orbiter.

Looking to the future, mission planners weighed concepts for a new mission that could orbit Jupiter's moon Europa, a world that shows strong evidence for an ocean of liquid water beneath its icy crust possibly hosting conditions favorable for life.



Gravity maps of Earth's moon, rendered from data collected by the twin GRAIL spacecraft. In these false-color views, red indicates zones of high gravity, while blue represents the opposite.

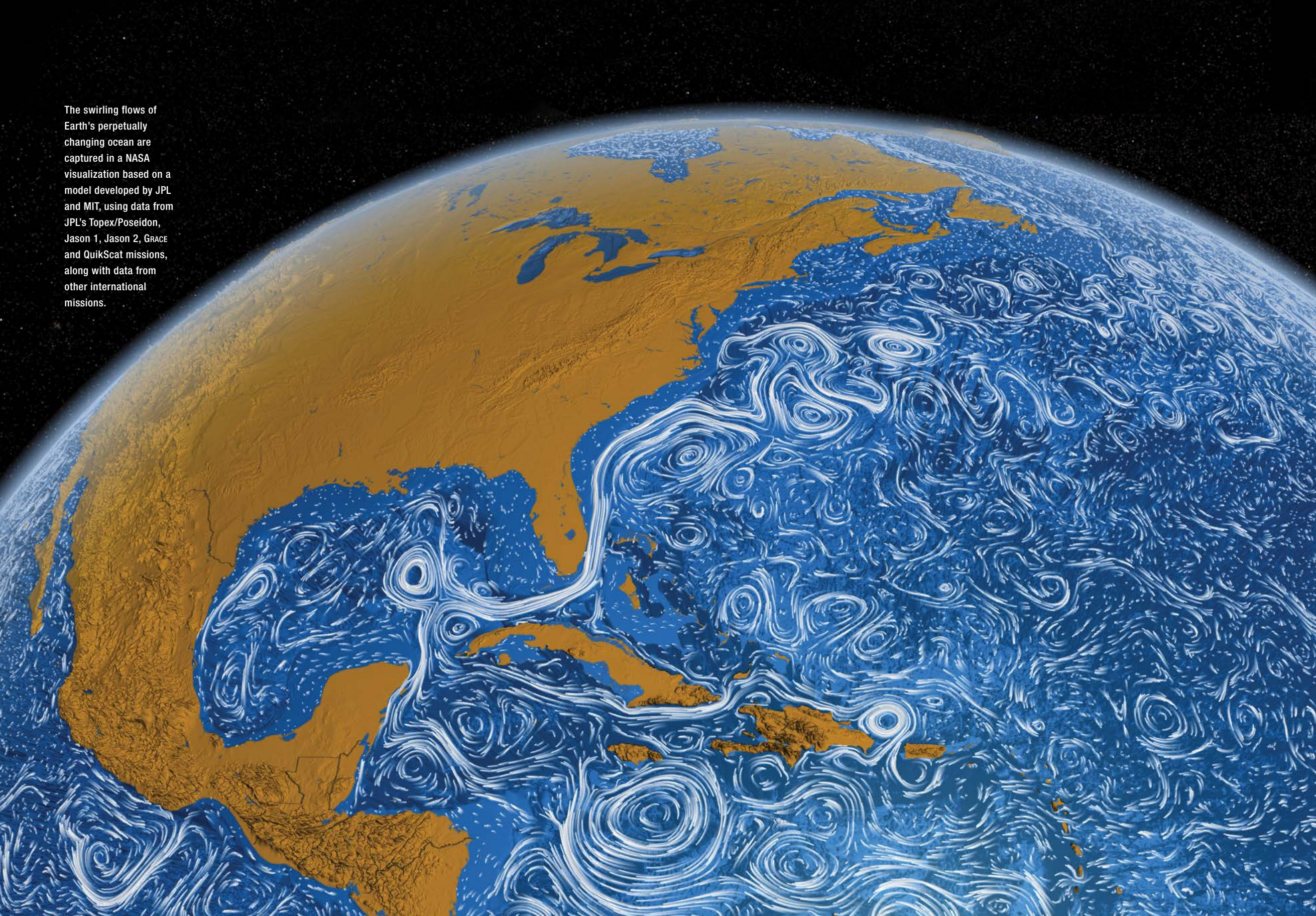
The Home Planet

One of the most active of JPL's research areas accounting for one-third of the laboratory's work, Earth science in 2012 included far-flung efforts ranging from satellites and instruments to studies by the laboratory's cadre of 150 scientists dedicated to examining our home planet.



Monitor, Measure, Track.

Earth explorers (from left) Jason Hyon, Howard Eisen, Shawn Goodman, Wendy Edelstein, Jim Graf, Christian Frankenberg, Josh Willis, Stacey Boland, Jennifer Rocca, Gun-Shing Chen.



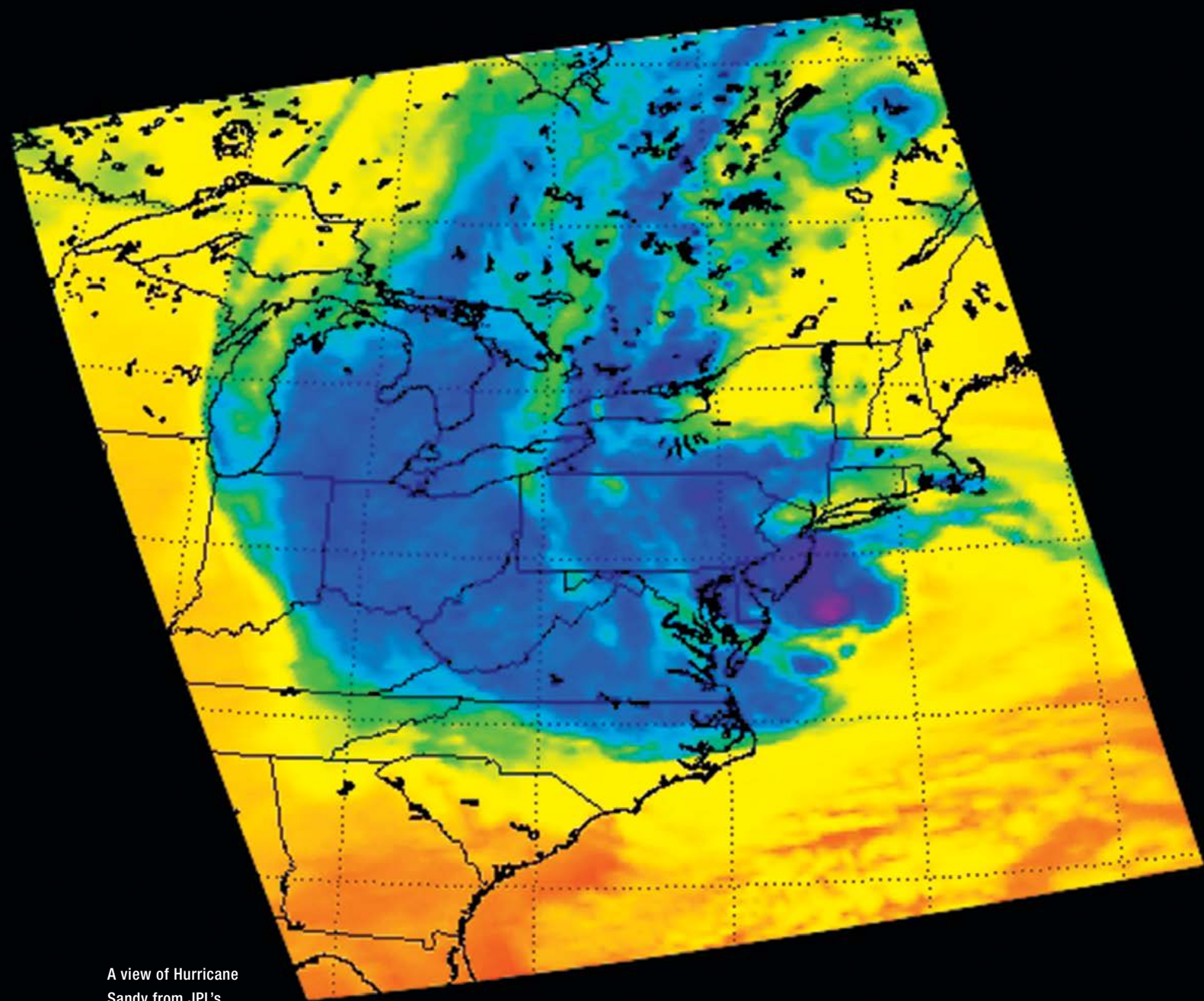
The swirling flows of Earth's perpetually changing ocean are captured in a NASA visualization based on a model developed by JPL and MIT, using data from JPL's Topex/Poseidon, Jason 1, Jason 2, GRACE and QuikScat missions, along with data from other international missions.

Among those investigations, JPL Earth scientists spent considerable time examining ice loss at both of Earth's poles. The most comprehensive and accurate study of ice sheet loss in Greenland and Antarctica was released in November by an international team using data from several satellites and aircraft. They found that more than three times as much ice is being lost each year as in the 1990s, with about two-thirds of the loss coming from Greenland and the rest from Antarctica. Another JPL study found that, for several days in July, Greenland's surface ice cover melted over a larger area than at any time in more than 30 years of satellite observations.

JPL's Gravity Recovery and Climate Experiment, or GRACE, mission showed that between 2003 and 2010 the total global ice mass lost from Greenland, Antarctica and Earth's glaciers and ice caps was about 4.3 trillion tons, adding about 0.5 inch to global sea level.

Hurricanes and other major storms were the focus of studies using JPL's Earth-orbiting satellites and instruments. As Hurricane Sandy bore down on the United States' East Coast in late October, images were collected by CloudSat as well as the Atmospheric Infrared Sounder and Multi-angle Imaging SpectroRadiometer instruments. Scientists also used data from the Atmospheric Infrared Sounder to analyze nearly 200 North Atlantic hurricanes. They concluded that relative humidity around a storm can be an important factor for how quickly a hurricane is likely to intensify.

In other wide-ranging studies, JPL Earth scientists looked at topics from climate warming to the 2010 Gulf oil spill to the role of clouds in weather and climate, and the health of forests.



A view of Hurricane Sandy from JPL's Atmospheric Infrared Sounder instrument.



I grew up in Florida, and I remember one summer when I was in elementary school a little before my birthday, Hurricane Andrew struck. I went with my dad to help my grandmother, who lived in the hurricane path. That was the event that set me on my course — I knew then that I wanted to be a meteorologist. Later, after I had studied meteorology in college, I got interested not just in looking at storms but also how they interact with the ocean, and got a degree in marine science. I'm interested not only in the physical response of the ocean to storms, but also its biology and how these events affect ocean life. In 2011 I came to JPL and have been working ever since with data from a variety of different missions. For me one of the best parts is not only working on understanding what's going on with the climate, but sharing it with the public. I've had opportunities to present at events from Climate Day to JPL's Open House to Girltopia to a visit by a U.S. senator. Sharing about what we do is a great joy.

Michelle Gierach
Scientist, Oceans and Ice



The Three Gorges Dam spanning the Yangtze River in east-central China, captured by the Advanced Spaceborne Thermal Emission and Reflection Radiometer instrument. The world's largest power station as measured by installed capacity, the site includes a vast reservoir stretching for 410 miles.

Yet other teams were busy working on the next round of JPL Earth science missions due for launch in 2014 and 2015. The coming missions include Orbiting Carbon Observatory 2, a satellite that will monitor carbon dioxide; Soil Moisture Active Passive, a mission designed to measure water in the top layer of Earth's soil to understand the planet's water, carbon and energy cycles; RapidScat, an ocean wind monitor that will be installed on the International Space Station; and Jason 3, a satellite that will make highly accurate measurements of global sea level.

The universe is unimaginably vast — perhaps 200 billion galaxies, each containing billions of stars, stretching across unthinkably large expanses. Yet the modern age of space-based telescopes and new technologies has brought the most distant and ancient realms into reach. Questions that were once unanswerable are now possible for scientists to chase, and some of the most compelling are the targets of JPL's astronomy missions.



Alien Worlds, Dark Energy.

Astronomy and physics team members (from left) Greg Hickey, Allen Farrington, Suzanne Dodd, Jim Marr, Mike Werner, Dave Gallagher, Anita Sengupta.

The newest explorer took to space in June, when the Nuclear Spectroscopic Telescope Array, or NuSTAR, was launched by a rocket dropped from an aircraft over the central Pacific Ocean. Led by a principal investigator from Caltech, NuSTAR scans the cosmos in the highest energy X-ray light to study the most powerful, energetic and extreme phenomena in the universe, including black holes, supernova explosions and neutron stars. In the months that followed the launch, the mission delivered a stream of findings, including the first high-energy detection of a flare from the giant black hole at the center of our galaxy, and unique information about black holes in other galaxies.

Plying other niches of the energy spectrum, JPL's Wide-field Infrared Survey Explorer, or WISE, opened up a new view of the cosmos by releasing an atlas and catalog of the sky with more than half a billion objects. In August, the science team announced that the mission had turned up a bonanza of newfound supermassive black holes and extreme galaxies that astronomers waggishly called "hot DOGs," or dust-obscured galaxies. Closer to home, an extension of the mission called NEOWISE provided the best-yet assessment of the solar system's population of asteroids that could prove hazardous to Earth.

Kepler, the planet-hunting space telescope, churned out findings throughout the year. In January, astronomers announced they had spotted what were then the three smallest planets ever seen orbiting another star. All three were thought to be rocky like Earth. But because they orbit closer to their star, called KOI-961, they are too hot to be in what astronomers call the habitable zone where life as we know it might exist.

The venerable Spitzer Space Telescope, stationed off-planet for nearly 10 years, proved that it still had discoveries to deliver, including contributions to the growing number of discovered exoplanets. Astronomers using Spitzer found what was believed to be a planet two-thirds the size of Earth, orbiting a star only 33 light-years away. At the time that made it possibly the nearest world to our solar system that is smaller than our home planet.

Long-lived Voyager 1, planetary spacecraft turned astrophysical explorer, made the news as it was judged to have entered a new region at the far reaches of our solar system. Scientists believe that realm is the final area the spacecraft has to cross before reaching interstellar space.



High-energy X-rays captured by NUSTAR from two black holes in the nearby spiral galaxy IC 342 are shown in magenta, superimposed on a visible-light image.



The Helix nebula — actually a dying star throwing a cosmic tantrum — in a composite image from the Spitzer Space Telescope and the Galaxy Evolution Explorer.

I do astronomy, but I got my degree in physics. When I was in graduate school, my advisor was doing a lot of work with the cosmic microwave background, the faint glow left over from the Big Bang. Over time I became convinced that was the most interesting thing out there for me to work on. What brought me to JPL almost 15 years ago was the opportunity to work on Planck, a European Space Agency mission that we are partnered on. I built a prototype of one of the low-frequency receivers. Traditional astronomers use facilities such as telescopes, but don't necessarily build them. Whereas people who study the cosmic microwave background tend to come out of physics departments and do a lot of work with the hardware. I spent a lot of time soldering cables as a grad student. Now I'm excited about a new mission we're working on with the European Space Agency called Euclid that will study dark matter and dark energy. I was asked to be the project scientist on the U.S. side. That for me has to be the high point of the year.

Mike Sciffert
Research Scientist



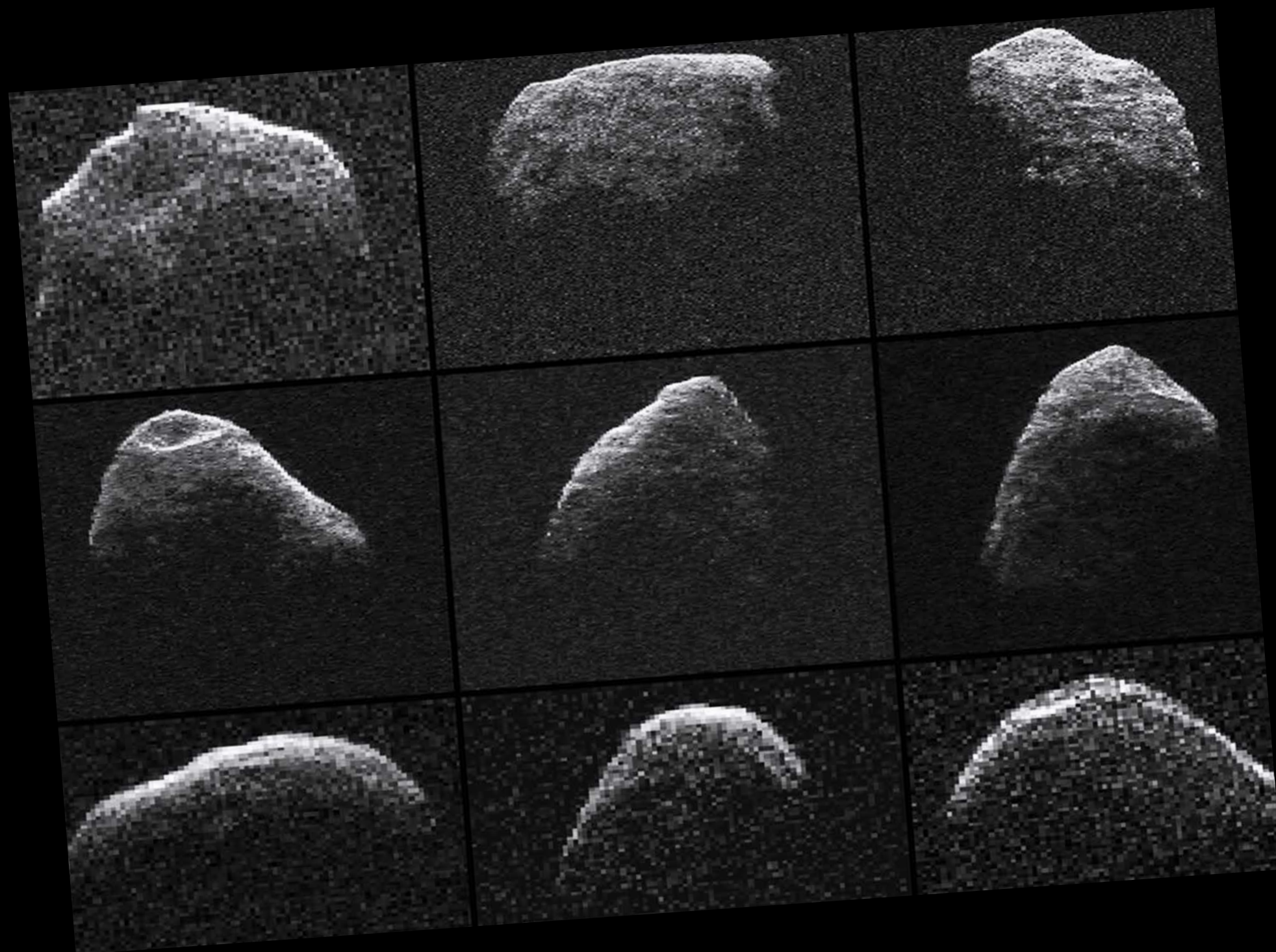
Interplanetary Network

A cosmic switchboard linking Earth with all of JPL's spacecraft beyond Earth's moon, the worldwide Deep Space Network doesn't stop. The network is alive at every hour, at complexes spanning three continents, its antennas slewing against the day or night sky, tracking, dispatching commands and receiving data from a host of solar system explorers.



Global Gateway.

Interplanetary Network team members (from left) Hamid Hemmati, Al Bhanji, Lorna Deady, Joe Lazio, Les Deutsch, Mike Levesque, Ana Maria Guerrero.



It is the communications portal not only for JPL's own missions, but also many others managed by other NASA facilities or tracked on behalf of international partners. In all, in 2012 the Deep Space Network tracked and communicated with 33 spacecraft for a total of 84,200 hours.

Mars Curiosity's landing presented special challenges to the network. During the rover's entry, descent and landing, the Deep Space Network tracked not only Curiosity but two JPL orbiters, Mars Reconnaissance Orbiter and Mars Odyssey, which were relaying telemetry from the rover to Earth. Three antennas not only tracked two spacecraft each, but also combined their signals to enhance reception and ensure highly reliable data return during the highly critical event. This approach enabled quick return of key information from the rover, including an image of its descent by parachute captured by Mars Reconnaissance Orbiter. For the remainder of the year after Curiosity's landing, the Deep Space Network delivered some 500 megabits of science data from the rover every day relayed through the two Mars orbiters.

Back on Earth, another focus for the Deep Space Network was an ongoing program of construction at its complex in Canberra, Australia, to deploy a new generation of antennas. In 2010 the network embarked on a long-term program of backing up its aging fleet of 230-foot-diameter dishes with new 112-foot antennas using newer technology to communicate more efficiently. The newer antenna design, called "beam waveguides," can operate on several different frequencies with a single antenna simultaneously. They also receive wider-bandwidth signals in the higher frequency spectrum known as the Ka-band. Over the course of 2012, one of the new antennas began to take shape in Canberra while technicians built a new 80-kilowatt transmitter that will eventually be used across the global network.

At Goldstone in the California desert, scientists and engineers actively used the 230-foot dish as an imaging radar instrument to study space objects — frequently asteroids that made passes close to Earth. In November, Goldstone captured radar views of asteroid 2007 PA8, and a month later imaged asteroid Toutatis as it slowly tumbled by.



With dozens of flying spacecraft

that need to talk to ground stations around the world on three continents, things can definitely get hectic. There are times I feel like I'm juggling five balls in the air at once — or even more. The important thing is making sure that all of the missions get the coverage they need, and we make it happen. My job is to act as the interface between each flight project and the Deep Space Network. I personally handle the Dawn mission and three future NASA missions that will use the Deep Space Network. I also served as deputy mission interface manager for Mars Science Laboratory's entry, descent and landing. The week before the Mars landing was extremely busy — we were reporting status at several meetings a day, and we had a lot of work to do to make sure that all the stations were ready. No question, the highlight of my year was being in the Space Flight Operations Facility the night of the Mars Curiosity landing. That's the kind of experience you never forget.

Felicia Sanders

Deep Space Network Mission Interface Manager



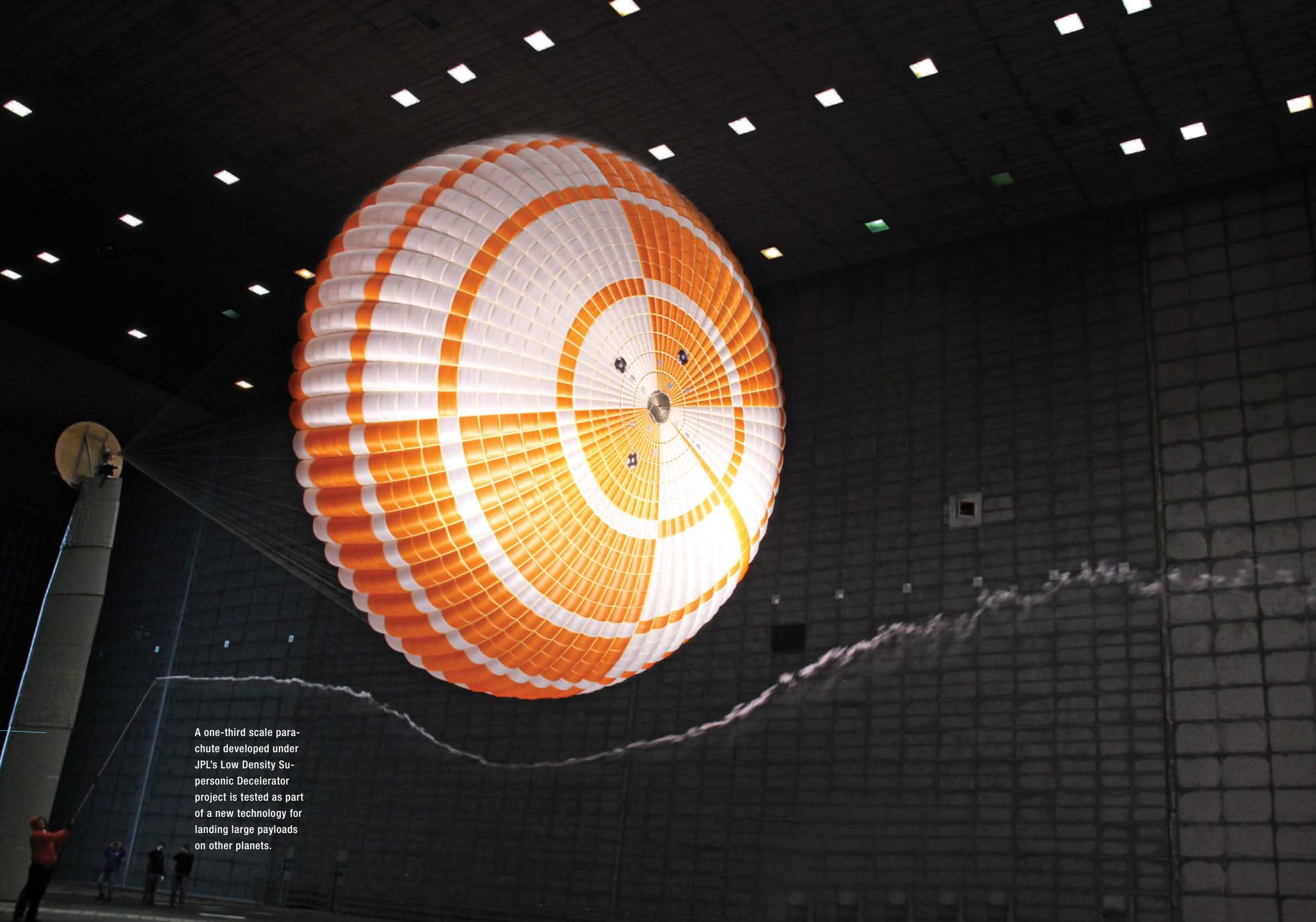
The Deep Space network's towering 230-foot dish at Goldstone, California.

Science and technology are at the core of everything JPL does — generating the questions that drive its missions, and lending the ways and means that make them possible. To keep these aptitudes strong, the laboratory pays special attention to sustaining these communities.



Pushing Boundaries.

Technologists and scientists (from left) Gerard Holzmann, Colleen Marrese-Reading, Aaron Parness, Marco Velli, John Prestage, Ashwin Vasavada, Lorene Samoska.



A one-third scale parachute developed under JPL's Low Density Supersonic Decelerator project is tested as part of a new technology for landing large payloads on other planets.

JPL's population of scientists, about 350 in all, includes about 100 planetary specialists, 150 Earth scientists and 100 astrophysicists. Their numbers are continually refreshed by the laboratory's very active postdoc program, as well as visiting scientists invited to JPL. In addition to participating on science teams and conducting independent research, JPL scientists frequently wear many other hats, carrying out roles in areas such as mission planning.

Both scientists and technologists benefit from JPL's Research & Technology Development Program, a fund created nine years ago to enable innovative technology development and science investigations. In 2012, grants to JPL staff spanned a diverse range of fields ranging from novel sensors, propulsion and computing to scientific studies in Earth science, planetary science and astronomy.

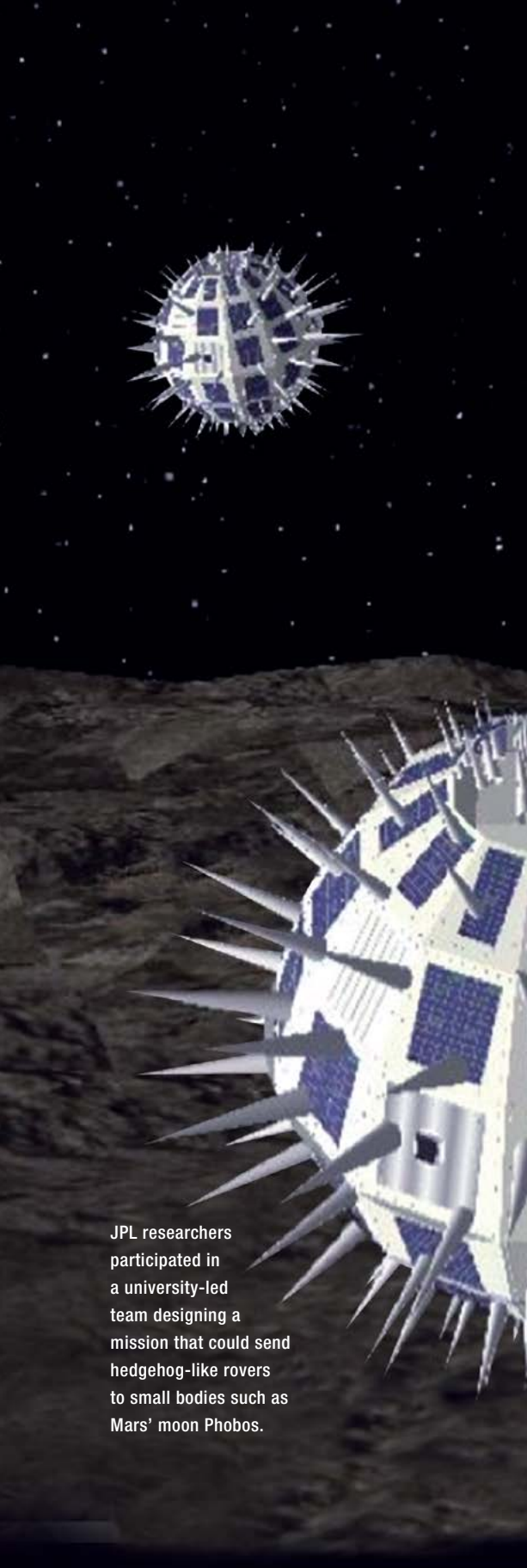
Founded in 1989, JPL's Microdevices Laboratory continues to be a birthing ground for microtechnologies and nanotechnologies. Researchers developed a "Lab-on-a-Chip," small devices that can analyze organic compounds in environments such as Saturn's moon Titan in search of the fingerprint of complex molecules.

Many technologies are devised as ways to solve problems for space missions. JPL began work on the Low-Density Supersonic Decelerator, a new approach to land on other planets with payloads that are too

massive for techniques such as airbags. Another project, the Deep Space Atomic Clock, is designed to revolutionize navigation by enabling a spacecraft to calculate its own timing and navigation data as it flies. Also receiving considerable attention were Cubesats — nanosatellites weighing about three pounds each — which promise to be a flexible way to send payloads into space at limited cost.

JPL is also supporting NASA's human exploration by developing instruments for the International Space Station. Besides potentially designing and flying robotic missions that serve as precursors to astronaut expeditions, JPL can also provide two of its special capabilities, deep space communication and the space navigation for which it is known as a world leader.

JPL's reimbursable work for non-NASA sponsors brings the laboratory together with a variety of commercial, government and international partners. In 2012, JPL worked with the Chevron Corporation on autonomous underwater robots to monitor deepwater oil pipelines at offshore sites. On behalf of the government of Kuwait, JPL flew a sounder instrument over arid deserts to identify sources of freshwater lying far below the sand. The laboratory also delivered imaging spectrometers to the Department of Defense, the National Science Foundation and the Carnegie Institution. Flown on airplanes, those hyperspectral imagers can map land uses, mineral signatures, deforestation and water resources.



JPL researchers participated in a university-led team designing a mission that could send hedgehog-like rovers to small bodies such as Mars' moon Phobos.

In my 11 years at JPL, I've worked on Europa, Titan, asteroids, laboratory work, Mars, astrobiology and mission design, planning and operations. In France, where I grew up and went to university, the specialty you major in pretty much defines your career path, with little opportunity for scientists to do engineering work. Coming to the U.S. opened more directions for me. I first came to JPL as a postdoc on Cassini, participating in science planning for icy moon observations, then I moved on to do lab work, simulating space environments in the laboratory. Then from icy moons I went to icy asteroids, and that led to Dawn — I will be focusing a lot on that as the spacecraft gets to Ceres. I also got involved in small spacecraft, working on a concept for a mission to send small hedgehog rovers to Mars' moon Phobos, and that in turn led to working on other small systems, including Cubesat spacecraft to test hardware beyond the orbit of the moon. At the beginning of 2012 our team for the hedgehog concept got together, and major aspects of the design started falling in place. That was very exciting! The team is really great, and for me as a scientist it was like, wow, it's so cool to be working on this.

Julie Castillo-Rogez
Scientist



Ion propulsion is what my entire career has been about — it's what I've worked on since I came to JPL in 1985. In the '80s and '90s, we developed ion thrusters in the lab. It turns out that they are easy to make to work well, but hard to make last long enough to be useful for space missions. So we modified designs, installed new test facilities, ran long-term tests and worked it out. When NASA's New Millennium Program came along, we flew an ion engine on Deep Space 1 as a technology demonstration, then flew three on Dawn as the first science mission to use ion propulsion. Now we're proposing a mission to retrieve an entire near-Earth asteroid. That would use an ion propulsion system 16 times more powerful than Dawn's. The high point of 2012 for me was when we tested a new ion propulsion system approach in the lab at JPL. This drove an ion thruster directly from a high-voltage solar array on the roof, with nothing in between but a simple capacitor. The tests went so well that we expect such direct-drive systems to revolutionize in-space transportation.

John Brophy
Engineering Fellow

Public Engagement

Just as today's sophisticated spacecraft are far beyond the relatively simple machines launched in JPL's earliest days, the way the laboratory communicates with the public has evolved no less dramatically. In this online era, new tools and platforms offer rich experiences for the public that wouldn't have been imaginable even a few years ago.



Inspire, Educate, Share.

Communicators and educators (from left) John Beck, Annie Richardson, Blaine Baggett, Allison Sengstacken, Marian Inova, Adrian Ponce, David Delgado, Kevin Hussey.

In 2012, those capabilities converged to create entirely new ways for the public to take part in Mars Curiosity's landing, turning it into NASA's largest Internet event ever — rivaling public spectacles such as British Royal Weddings and the Olympics.

As the landing approached, JPL took full advantage of social media platforms such as Twitter and Facebook. The laboratory's @MarsCuriosity Twitter account soared from 120,000 followers before landing to more than 1 million a week later. Social media efforts overall provoked more than a billion potential impressions.

"Seven Minutes of Terror," a gripping video on the challenges of Mars Curiosity's entry, descent and landing, went viral online and attracted about 10 million viewers. JPL retooled "Eyes on the Solar System," an online app that allows users to view planetary and Earth spacecraft all across the solar system, so that it could deliver a high-fidelity simulation of Curiosity's landing during real events on arrival night. The app was so popular that it attracted more than a million visits during landing week and pumped out 18 terabytes of data to users. Hosted on a cloud environment to ensure that unprecedented public demand was

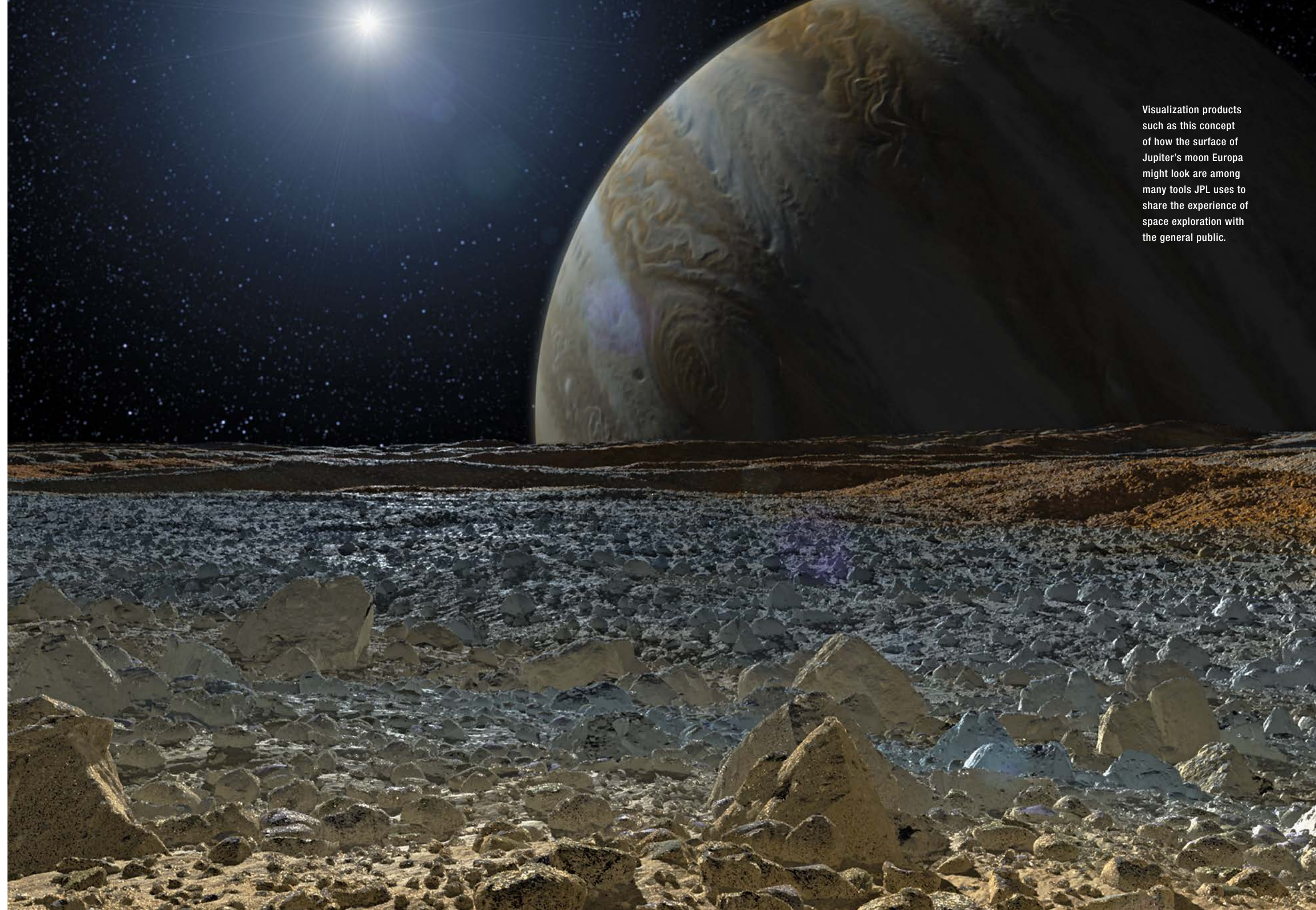
met during peak landing times, the Mars public engagement website saw more than 7 million unique daily visitors.

Television feeds from JPL were sent to public events in settings ranging from museums to schools to NASA centers, and even New York City's Times Square. In all, 11 million-plus viewers watched live television coverage of the landing.

To ensure preservation of the laboratory's history, JPL released a 90-minute documentary on the first missions to Mars in the 1960s and 1970s.

Not all of JPL's public engagement efforts were focused on Mars. With two dozen spacecraft flying and new discoveries being made almost daily, there was never a lull in being able to share with the public — through the media, Internet, in classrooms and museums — the excitement of space exploration.

Visualization products such as this concept of how the surface of Jupiter's moon Europa might look are among many tools JPL uses to share the experience of space exploration with the general public.





The Mars Curiosity landing was JPL's biggest flight event in years, so it called for the most extensive social media campaign we've ever mounted. Before, during and after the landing we used many elements, ranging from Twitter tweets to Facebook postings to web-streamed television. The day after the landing, we learned that 3.2 million viewers had watched live commentary via our channels on Ustream.tv. We'd been concerned because, outside of the west coast, U.S. newscasts had already ended before the landing occurred. Seeing the metrics, and knowing we had more viewers on our channel than what the three major cable news channels combined have in one evening, was a moment to cheer.

Veronica McGregor

Manager, Media Relations

After landing, the Internet wanted to know more about the people behind the mission. Forbes published a story that noted the engineers in mission control as well as our all-female social media team. It prompted a JPL fan to tweet, "It's a good change when the guys are noticed for their hairstyles & the ladies for their work." Nothing against mohawks, pompadours or the brains beneath them, but it made me proud that we were celebrated for our humor and tight writing.

Stephanie Smith

Social Media Specialist

On the eve of landing, our Curiosity Twitter account received a peculiar invitation — a one-on-one Twitter chat with astrophysicist Neil DeGrasse Tyson, open for all other Twitter users to see. For over an hour, we responded in the voice of Curiosity to questions from Dr. Tyson on topics including space travel, science experiments, and whether the rover prefers scientists or engineers. The Internet was abuzz, and within minutes Curiosity gained thousands of new followers and well-wishes on the impending landing.

Courtney O'Connor

Social Media Specialist



Achieving Excellence

JPL's successes depend not only on the work of its engineers and scientists, but also on the many systems of infrastructure that enable them. Making them as efficient as possible is the focus of initiatives across disciplines ranging from technical leadership to business systems, human resources and information technology.



Making Great Things Possible.

Business, human resources and IT specialists (from left) Paula Caterina, Kevin Endo, Marisa Gamboa, Brian Johnson, Charles Wainwright, Leslie Guilbault, Debby Callaghan, Bill Seixas.



One major thrust in 2012 was to ensure that JPL's institutional environment is optimized not only for the development of large flight projects, but also small and medium missions that involve high levels of technology infusion. JPL's engineering and science leadership examined organizational changes designed to provide strong support for innovative mission formulation, architecture and system engineering. Implementation of proposed changes was anticipated in 2013. JPL's mission assurance leadership rolled out tailoring guidelines for flight projects of various risk classifications to address the needs of small and medium higher-risk missions.

The laboratory's leadership also considered initiatives designed to foster creativity and innovation through programs such as technical mentoring and projects focused on involvement of early career hires. Other initiatives included model-based system engineering to better manage increasing complexity of missions, as well as updating of engineering and quality-reliability processes to achieve compliance with the AS9100 standard for quality management systems within two years.

A highlight in the business sphere was the successful negotiation of a new five-year prime contract between NASA and Caltech for the management of JPL, the space agency's only federally funded research and development center. The new contract took effect September 30, 2012 and will run through 2017. Other business highlights included successful execution of an independent assessment program to analyze financial performance, and strengthening

cost estimating and project controls. JPL also expanded the content and scope of an online system to manage photography in support of flight projects, and broke ground on a long-awaited parking structure.

With cyber threats of various kinds continually increasing, JPL took steps to safeguard its assets with a number of IT security efforts. These included two-factor authentication required for JPL personnel to access the laboratory's network remotely via virtual private networks; full disk encryption for laptops; and security reviews of JPL's external websites. In 2012 JPL expanded its use of cloud computing, making use of the cloud to support the Mars Curiosity mission both for its technical processing needs as well as for presentation of public web content during key traffic periods.

Leadership development was a focus in the human resources realm, with new training programs rolled out for technical and business supervisors and managers. The laboratory also conducted an employee engagement survey to identify areas for organizational and management improvements to engage JPL's staff as fully as possible in all aspects of the work environment.

As the number of non-spaceflight experiments at JPL increased, safety plans were developed for 87 campaigns conducted by JPL researchers in remote, isolated and hazardous locations, all of which were successfully carried out without incident. JPL's recycling program succeeded in diverting 80 percent of the laboratory's total waste from landfills during the year.



JPL's operations depend heavily on our business information system — it's the platform that hosts more than 100 applications, from timekeeping to inventory to budgets. In 2010 we learned that there was a major version upgrade we would need to install to keep current and stay in compliance with federal and state laws. So we knew this was going to be a big task. All told, getting the system upgraded took up to 150 people working over 18 months — functional partners, system administrators, database administrators, security engineers, analysts, developers and many more. On the final weekend, we took the system down and had about 100 people working 24/7 in different shifts. When Monday morning came, everything worked.

Scott Yeats

Manager, Finance and Acquisition Business Systems

Of course we had to carry on with our regular day-to-day jobs while doing this. It required not one but a series of nine sequential upgrades to practice, test and update the software. For me, the big moment was when we had the go-live readiness review with stakeholders, executive and division management, and the chief financial officer. When everyone gave us a unanimous thumbs-up, I felt really good — we knew we were in good shape.

Melanie Chau-Budman

Manager, Logistics, Acquisition, Manufacturing and Payables



Sami Asmar
International Committee on Technical
Interchange for Space Mission Operations
and Ground Data Systems
International Exceptional Achievement Medal

Amy Braverman
American Statistical Association
Named Fellow

Cassini Mission
National Air and Space Museum
Trophy for Current Achievement

Ian Clark
National Science and Technology Council
*Presidential Early Career Award for Scientists
and Engineers*

Riley Duren
The Engineers' Council
Distinguished Engineering Achievement Award

David Durham
The Engineers' Council
*Outstanding Engineering Achievement
Merit Award*

Dan Goebel
American Physical Society
Named Fellow

Olivier Guyon
MacArthur Foundation
Named Fellow

Gerard Holzmann
Association for Computing Machinery
Named Fellow

Dave Linick
International Committee on Technical
Interchange for Space Mission Operations
and Ground Data Systems
International Distinguished Service Medal

Mars Reconnaissance Orbiter Team
National Space Society
Space Pioneer Award

Mars Science Laboratory
Space Foundation
*Jack Swigert Jr. Award for Space
Exploration*

Robert Mase
The Engineers' Council
*Distinguished Engineering Project
Achievement Award*

Thomas Painter
Cryosphere Focus Group, American
Geophysical Union
Elected President

Humphrey Price
The Engineers' Council
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Award*

Art Rankin
National Society of Black Engineers
*21st Century Trailblazers in Aerospace
Award*

Marc Rayman
The Engineers' Council
*Outstanding Engineering Achievement
Merit Award*

Amit Sen
The Engineers' Council
*Distinguished Engineering Project
Achievement Award*

Anita Sengupta
American Society of Engineers of
Indian Origin
Engineer of the Year

Ashitey Trebi-Ollennu
National Society of Black Engineers
*21st Century Trailblazers in Aerospace
Award*

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Soil Moisture Active Passive

Total Costs



Total Costs by Program



Total Personnel



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Artist's depiction of a
candidate exoplanet
called UCF-1.01 some
33 light-years from
Earth, detected by the
Spitzer Space Telescope.



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