

Mars Science Lab marches on Rover mission now targets October 2011

By Mark Whalen

Due to critical testing and hardware challenges that must be addressed to ensure success, the launch of JPL's Mars Science Laboratory has been postponed to fall 2011. Lab Director Charles Elachi praised the achievements of the mission team in coming very close to making the 2009 launch opportunity and said he expects eventual success.

"It's amazing what the MSL team has done," Elachi said. "But I promised them that we would not launch in 2009 unless the spacecraft meets our standards for testing and risk mitigation, and I give them a lot of credit for letting me know that their progress didn't come fast enough on solving technical challenges and pulling hardware together."

The project is currently working on a plan of implementation for an October 2011 launch. The rover is now undergoing testing in JPL's space simulator. Planned testing and development activities will continue, but at a more measured pace.

As for Mars Science Laboratory personnel, Elachi said a roll-off of employees in the winter would proceed as planned. He is also confident that other positions can be found in the near term for the "vast majority" of Mars Science Laboratory staff.

Bearing in mind the launch delay and uncertainties about NASA's still-pending FY '09 budget—as well as consideration of the FY '10 budget a few months later—JPL in general will be working to cut costs where possible.

"We are looking at things we can defer in the near term, and will encourage steps such as reduced travel," Elachi said. "We are considering numerous options except where personnel safety and flight hardware would be compromised."

As always, JPL has learned some lessons from the Mars Science Laboratory experience that will help future missions.

The ever-challenging task of cost estimation was made much tougher due to the fact that Mars Science Laboratory was a first-of-its-kind mission with amazing new capabilities, Elachi said. Successful techniques used to extrapolate expected costs based on previous missions didn't work well this time, he noted.

"MSL is such a huge jump in what we need to learn," Elachi said. "This time was an extrapolation to a factor of five or more in capability compared to ever before."

Indeed, Elachi called Mars Science Laboratory, in every respect, the most difficult and most challenging mission JPL has ever undertaken.

"It's like three spacecraft in one—the cruise stage, descent stage and rover. It's an amazing machine, one that must survive many years," he said. "But these are



Mars Science Laboratory team members pause for a portrait during assembly, test and launch operations in the Spacecraft Assembly Facility.

the kinds of projects we're expected to do. We have the best team in the world, if not the only one, that can do it.

"When we went to NASA Headquarters with the issues we are facing, to their credit, Mike Griffin (NASA administrator), Ed Weiler (associate administrator for the Science Mission Directorate) and

Chris Scolese (NASA associate administrator) all agreed that mission success is the most critical thing," Elachi added.

"Costs and schedules are taken very seriously on any science mission," Weiler said. "However, when it's all said and done, the passing grade is mission success."

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The Mars Program I recall

Mars Science Laboratory's origins and budget have been the topic of recent news coverage. Here they are discussed by Firouz Naderi, JPL's associate director for project formulation and strategy and former manager of the Mars Exploration Program. Named to the Mars position in April 2000 following the twin losses of Mars Climate Orbiter and Mars Polar Lander, he was part of a group that re-architected the Mars Program, which he then managed for the first half of this decade.

HOW DID MARS SCIENCE LABORATORY ORIGINATE?

In the summer of 2000, a core group of us picked by Ed Weiler [then associate administrator of NASA's Office of Space Science] were tasked to re-architect the Mars Program for the next decade. With input from hundreds of folks from the science, aerospace and international space communities, we put together a program that contained a chain of scientifically, technologically and operationally coupled missions. The program was specific on the 2001 opportunity (Mars Odyssey) and 2003 (Mars Exploration Rovers), but beyond that the missions were notional. One of the future missions, planned for 2007, was called Mars Smart Lander. I coined

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the name because we wanted to introduce sophisticated technologies for a future class of advanced landers. Initially this mission's focus was definitely on technology. It later evolved to become the current Mars Science Laboratory (MSL), with extensive science and engineering capabilities.

IN SOME QUARTERS IT IS BEING ARGUED THAT THE START OF MSL, AND THEREFORE ITS INITIAL COST, SHOULD BE TIED DOWN TO A DECADAL REPORT ISSUED BY THE NATIONAL ACADEMY OF SCIENCES IN 2003. HAD THE DEFINITION OF MSL GELLED BY THEN?

In 2000–2003 MSL definition was still maturing. This can best be seen in records of the Committee on Planetary and Lunar Exploration and the National Research Council, both of which published discussions about NASA's Mars Program. In documents from that time period it's obvious that there were still open questions about issues such as whether MSL would be technology- or science-driven, and whether it would be nuclear-powered.

THE NATIONAL RESEARCH COUNCIL'S REPORT LISTED MSL AS A MODERATE MISSION, BUT WE KNOW THAT THE MSL OF TODAY IS A FLAGSHIP MISSION. WHY WAS THE SCOPE OF THE MISSION EXPANDED?

A principal tenet of the Mars Program we defined in 2000 was that it would

build future missions based on the findings of prior missions. The projects later in the decade were penciled in as general concepts with the intent that they would be further defined in response to discoveries made on Mars. As we got closer to the MSL timeframe, NASA decided to make the mission much more scientifically capable and nuclear-powered. This transformation did not happen, as some have suggested, behind closed doors. Instead, NASA vested a science definition team to spell out the objectives for an MSL that would build on the discoveries of missions already flown, including the Mars Exploration Rovers Spirit and Opportunity. NASA's Mars Advisory Group adopted these new objectives. MSL's engineering capabilities were also increased in response to a National Research Council recommendation that it test and validate technology required for sample return. For example, the current MSL can land a metric ton of hardware on Mars, which is expected to be a requirement for the sample return mission.

THERE HAS BEEN RECENT DISCUSSION IN THE NEWS MEDIA ABOUT THE COST GROWTH OF MSL AND THE MARS PROGRAM AS A WHOLE. SOME SAY THE MSL BUDGET HAS GROWN BY 300 PERCENT. CAN YOU COMMENT ON THIS?

Well, you asked two questions—cost growth of the program, and cost growth of MSL. Let me take them in order. From the outset the fiscal policy of the

Mars Program and the direction from Weiler had been that, as additional funds were needed to implement or complete any of its elements, we had to secure those funds from within the Mars Program. For example, Spirit and Opportunity eventually required 18 percent additional funds to complete their missions within an impossibly tight schedule. Moving MSL from 2007 to 2009 helped with that.

Later, as the medium-class MSL evolved to a flagship mission, once again the Mars Program solved the need for additional resources from within. A planned dedicated communication spacecraft called Mars Telecom Orbiter was eliminated, in part because the existing science orbiters had proved to function so well as relay satellites; the funds were transferred to MSL. Additionally, the French space agency decided that they did not have the funds to continue with a mission called Mars Netlanders that had been intended as a partnership with NASA. Our program used the funds it had set aside for this mission to complete the funding needs for MSL. So the Mars Program has lived within its means.

Now as to your second question, the cost of MSL at its confirmation review in August 2006—shortly after completion of its preliminary design review—was \$1.63 billion. Confirmation review is a juncture in the program where we and NASA feel we have reasonable information to bound the cost of the mission with 70 percent probability. This is

when we as the implementing organization make a commitment to NASA, and NASA in turn makes a commitment to Congress. However, MSL has proved even more challenging than what its preliminary design review had exposed. By this fall, the cost of MSL for a 2009 launch had grown by about 25 percent to \$2 billion.

So where does the 300 percent come from? A former NASA official insists on comparing the current mission with the earlier notional moderate-class mission in the National Research Council report. But in terms of requirements and objectives, that early notional mission and the current, vastly more capable flagship mission are apples and oranges. NASA consciously decided to fly the more capable mission.

WHY CAN'T THE ADDITIONAL FUNDS NEEDED FOR MSL COME FROM THE MARS PROGRAM ITSELF? DIDN'T YOU SAY THAT THAT IS THE PROGRAM'S POLICY?

In the 2009 budget process, the previous associate administrator for NASA's Science Mission Directorate diverted \$640 million of Mars Program funds in years 2009–2011 to other programs of his choice. This left the Mars Program with no flexibility to adjust its budget as it had done successfully earlier in the decade. My successor, Fuk Li, would have been able to solve Mars Science Lab's cost growth within the program resources had he been left

*Continued on page 8***Mars Science Lab***Continued from page 1*

Also in agreement that the mission's postponement was the right call is U.S. Rep. Adam Schiff, who stopped by JPL on the day of the announcement to offer his support to Laboratory staff. Schiff represents California's 29th congressional district, in which part of JPL resides, and serves on the House Appropriations Subcommittee on Commerce, Justice and Science.

"We understand the challenges you're facing and would much rather see a decision that you want more time to get the technical challenges right than to take too much risk on something so big and so tough, and fail to succeed," Schiff told a full von Kármán Auditorium audience.

"It's the right decision, but a hard one," he added. "But my colleagues and I, on the subcommittee, the full committee and full House, and I'm sure in the Senate, support what you're doing. We know it's not easy. We want you to be open and candid with us when you run into challenges ... better that we know about it now than a year and a



Congressman Adam Schiff, standing next to JPL Deputy Director Gene Tattini, visited the Lab to show his support on Mars Science Laboratory. From left: Project Manager Richard Cook, JPL Mars Program chief Fuk Li, and Patty Rhee of JPL's Legislative Affairs Office.

half from now, with an unsuccessful landing. So I hope you're encouraged."

Elachi, too, remains upbeat about the mission and about the Lab's future.

"I have no doubt we will launch in 2011," he said. "I'm confident that one day we will look back and say we used this time wisely. There is no doubt MSL will be NASA's flagship mission at the beginning of the next decade."

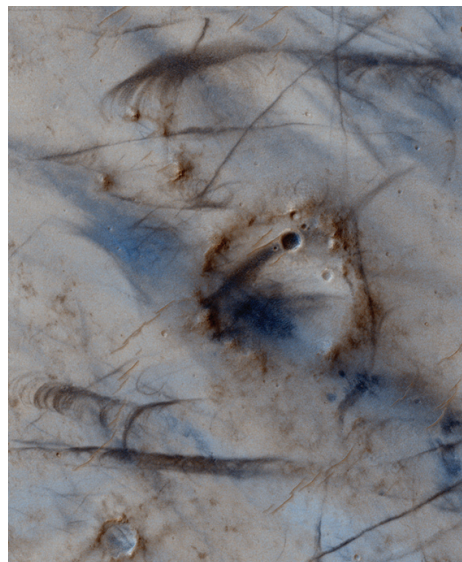
Elachi is also optimistic about NASA's role in the incoming Obama administration.

"All indications are positive," Elachi said. "President-elect Obama values science, in particular placing a high priority on understanding global change."

Schiff agreed. "I'm very encouraged about the new administration," he said. "I think it's going to be a breath of fresh air and a rededication to science."

In 2008, two JPL missions—the **Earth-orbiting Ocean Surface Topography Mission** and the **Moon Mineralogy Mapper** aboard India's first space project—joined 18 JPL spacecraft and 10 major instruments working across the solar system and beyond. During the year, **Phoenix** joined the still-active **Mars Exploration Rovers** on the Red Planet and operated for more than five months before succumbing to the harsh elements. Also at Mars, the **Reconnaissance** and **Odyssey** orbiters continued their work on extended missions. Cassini revealed still more secrets about Saturn and its moons. Astrophysics satellites and instruments sought out answers about star formation and other mysteries beyond our planet. And **JPL's roster of Earth science missions** moved forward on helping to deal with various aspects of climate change. The Laboratory faces possibly its busiest year ever heading into 2009. Here is a list of major JPL highlights for 2008.

2008 IN REVIEW

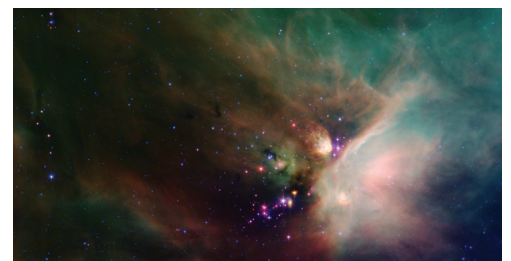
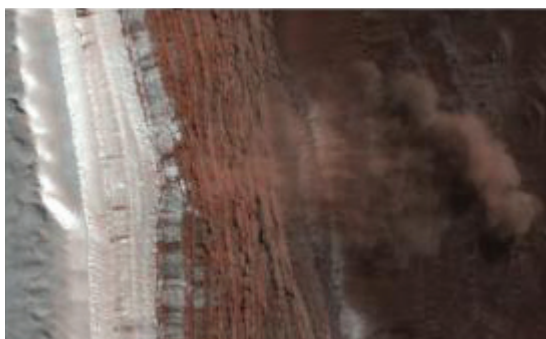
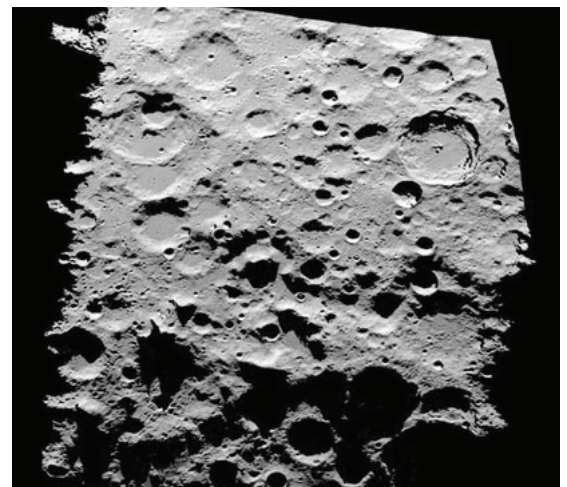


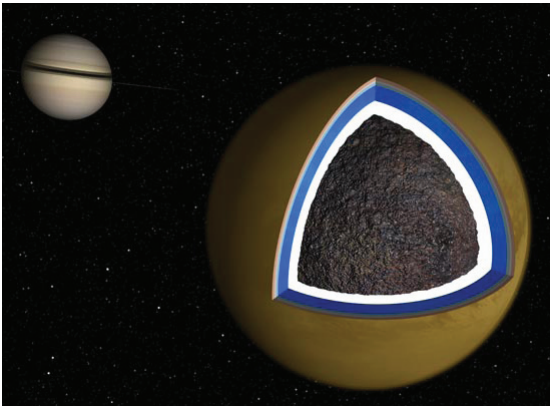
JANUARY

The Laboratory kicked off the new year with a float (far left) in Pasadena's Tournament of Roses Parade that highlighted the 50th anniversary of JPL's Explorer 1, the first U.S. satellite to orbit Earth. ... Based on work by its Nano and Micro Systems Group, JPL announced a partnership with the City of Hope, a leading cancer research and treatment center in Duarte, to explore the potential of carbon nanotubes to diagnose and treat brain tumors. If effective, the technology might also be used to treat other disorders and disease processes in the brain. ... New views of Mars geology from the camera on JPL's Mars Reconnaissance Orbiter showed that Mars has an ethereal, tenuous atmosphere with less than 1 percent the surface pressure of Earth, which challenges scientists to explain complex, wind-sculpted landforms seen with unprecedented detail (left). ... A study by JPL and Louisiana State University found that sediments deposited into the Mississippi River Delta thousands of years ago when North America's glaciers retreated are contributing to the ongoing sinking of Louisiana's coastline (far left, below). Co-author Ron Blom of JPL said that New Orleans is particularly vulnerable.

FEBRUARY

For the first time ever, NASA sent a song "Across the Universe." The Beatles' 1970 hit was transmitted over the Deep Space Network to commemorate the 40th anniversary of the day the Beatles recorded the song, as well as several NASA anniversaries. JPL technicians sent the command (near right) that started the transmission to the North Star, Polaris, which is 431 light years away from Earth. ... Newborn stars peek out from beneath their natal blanket of dust in a dynamic image (below right) of the Rho Ophiuchi dark cloud from JPL's Spitzer Space Telescope. Astronomers favor the region because the stars are so young and can be observed at a very early evolutionary stage. ... Mars Reconnaissance Orbiter took the first-ever image of active avalanches near the Red Planet's north pole. The image (below left) shows tan clouds billowing away from the foot of a towering slope, where ice and dust have just cascaded down. ... The highest-resolution terrain mapping to date of the moon's rugged south polar region (above right) was collected by JPL scientists using the Deep Space Network's Goldstone Solar System Radar. The imagery was incorporated into animation depicting the descent to the lunar surface of a future human lunar lander and a flyover of Shackleton Crater. The data indicated that the region of the moon's south pole near the crater is much more rugged than previously understood.



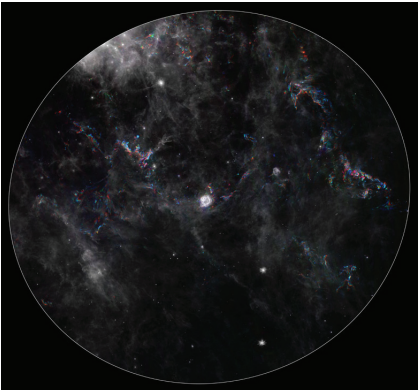
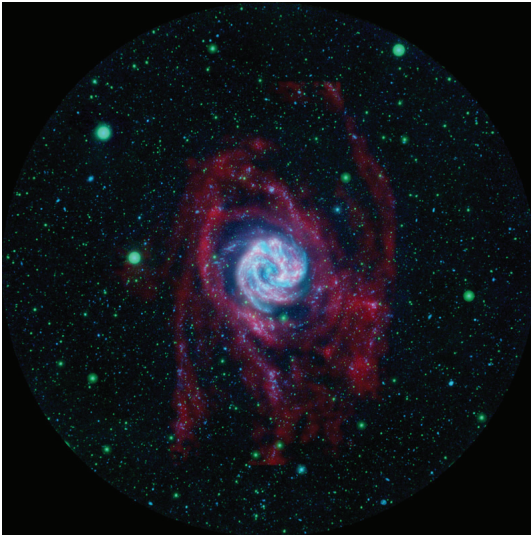


MARCH

Two technologies developed by JPL were selected for the Space Foundation’s Space Technology Hall of Fame. ArterioVision, initially developed in the 1990s and derived from software used to process spacecraft imagery, is used with a standard ultrasound to precisely measure the thickness of the two inner layers of the carotid artery, allowing doctors to better predict heart disease risk. The foundation also commended JPL mission-assurance manager Helenann Kwong-Fu for helping develop the technology and standardize protocols for image acquisition. Petroleum Remediation Product, the second technology honored, originated at JPL and NASA’s Marshall Space Flight Center. JPL demonstrated the feasibility of encapsulating live cells, while technology developed at Marshall for experiments in orbital production of microspheres gave the basic design of the delivery system. Industry scientists then worked with researchers at both NASA centers to develop the technology. ... Cassini performed a daring flyby of Saturn’s moon Enceladus March 12, flying through icy water geyser–like jets and coming within 50 kilometers (30 miles) of the surface at closest approach (top). The spacecraft snatched up precious samples that might point to a water ocean or organics inside the little moon. Scientists believe the geysers could provide evidence that liquid water is trapped under Enceladus’ icy crust. This was the first of four Cassini flybys of Enceladus this year. ... A team of astronomers led by JPL’s Mark Swain made the first-ever detection of an organic molecule in the atmosphere of a Jupiter-sized planet orbiting another star. The breakthrough was made with the near-infrared camera and multi-object spectrometer on the Hubble Space Telescope. The molecule found by the team is methane, which under the right circumstances can play a key role in prebiotic chemistry. “This is a crucial stepping stone to eventually characterizing prebiotic molecules on planets where life could exist,” said Swain. ... Scientists using Mars Odyssey’s thermal emission imaging system found evidence of salt deposits, which point to places where water once was abundant and where evidence might exist of possible Martian life from the Red Planet’s past. ... Using radar measurements of Titan’s rotation, Cassini discovered evidence that points to the existence of an underground ocean of water and ammonia on Saturn’s moon Titan (bottom). “We believe that about 100 kilometers (62 miles) beneath the ice and organic-rich surface is an internal ocean of liquid water mixed with ammonia,” said JPL’s Bryan Stiles, a contributing author to the paper that appeared in the journal Science.

APRIL

Among honors received by the Stardust team were Aviation Week & Space Technology’s Program Excellence Award; Popular Mechanics’ Breakthrough Award; the Space Club of Houston’s Rotary National Award for Space Achievement; and the National Air and Space Museum’s Trophy Award. ... JPL was named winner of the government’s Dwight D. Eisenhower Award for Excellence in the research and development category. The award recognizes large prime contractors who excel in using small businesses as suppliers and subcontractors. The JPL program, managed by the Business Opportunities Office, helps small businesses owned by veterans, women and minorities. This is the third time JPL has received the prestigious award. ... NASA announced a two-year extension for the Cassini-Huygens mission that will include 60 additional orbits of Saturn and more flybys of its exotic moons. The mission originally had been scheduled to end in July 2008. ... A new image from the JPL-managed Galaxy Evolution Explorer (right) showed baby stars sprouting in a relatively desolate region of space more than 100,000 light-years from the galaxy’s bustling center. The main stellar disk of the Southern Pinwheel galaxy looks like a pink and blue pinwheel, while its outer arms appear to flap away from the galaxy like giant red streamers. It is within these so-called extended galaxy arms that, to the surprise of astronomers, new stars are forming.

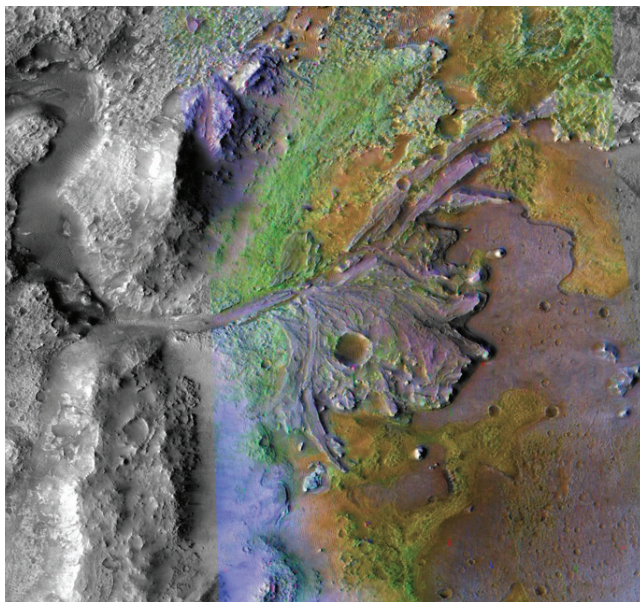
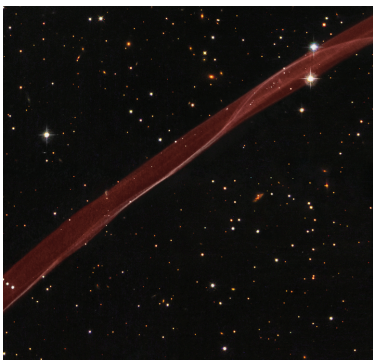
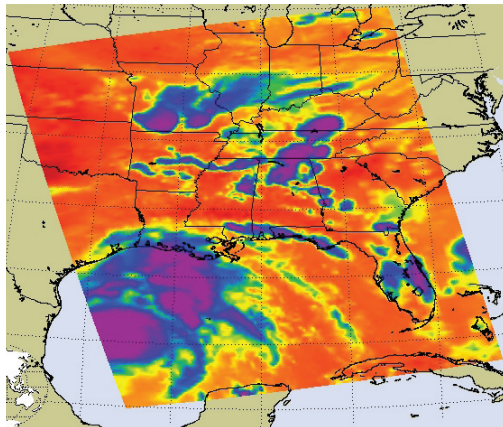
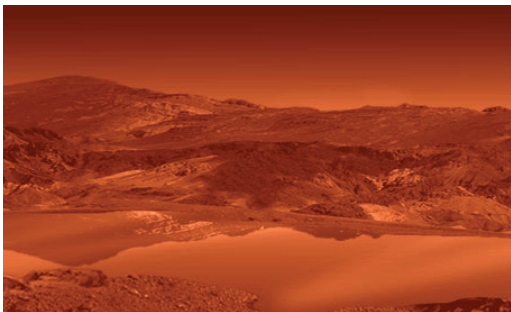
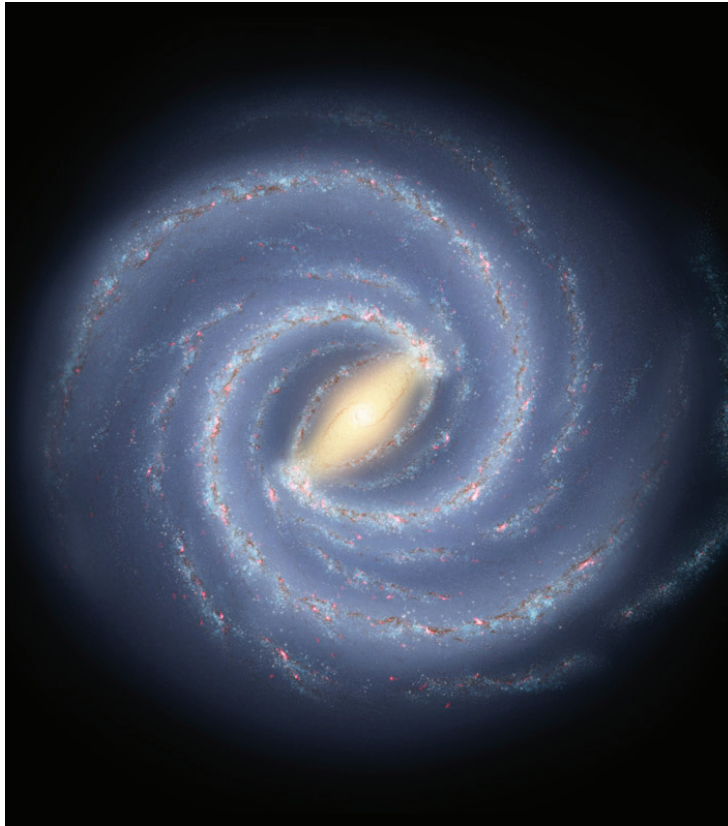


MAY

The Ulysses mission operations team received the International SpaceOps Award for Outstanding Achievement, bestowed by the International Committee on Technical Interchange for Space Mission Operations and Ground Data Systems in recognition of its contributions to the success and scientific productivity of the mission orbiting the poles of the sun. ... The Phoenix team (led by Project Manager Barry Goldstein, top) celebrated the spacecraft’s landing in Mars’ northern polar region to begin a three-month mission of examining Mars’ icy northern latitudes. ... Using data from instruments in a constellation of Earth-orbiting NASA satellites, scientists discovered that they can see deep inside of clouds. The satellites’ first-of-a-kind measurements shed new light on the link between clouds, pollution and rainfall. Jonathan Jiang of JPL and his team used the JPL-developed and managed Microwave Limb Sounder on NASA’s Aura satellite to measure the level of carbon monoxide in clouds. The presence of carbon monoxide implies the presence of smoke and other aerosols, which usually come from the same emission source, such a power plant or agricultural fire. ... A discovery based on data primarily from Spitzer and Japan’s Subaru telescope in Hawaii represents the first time astronomers have been able to resurrect the life history of a supernova remnant in our own galaxy. By decoding ghostly echoes of light traveling away from the remains of supernova Cassiopeia A, scientists pieced together (bottom) what the star looked like in life, and ultimately how it met its demise. ... The final piece of steel was installed in the structural framework of JPL’s new Flight Projects Center. Work continued toward occupancy in summer 2009.

JUNE

New images from Spitzer (top right) shed light on the true structure of the Milky Way, revealing that it has just two major arms of stars instead of the four it was previously thought to possess. The findings make the case that the Milky Way has two major spiral arms, a common structure for galaxies with bars. ... More than 800,000 snapshots from Spitzer were stitched together to create a new “coming of age” portrait of stars in our inner Milky Way galaxy. “This is the highest-resolution, largest, most sensitive infrared picture ever taken of our Milky Way,” said Sean Carey of Caltech’s Spitzer Science Center. “With this data, we can learn how massive stars form, map galactic spiral arms and make a better estimate of our galaxy’s star-formation rate.” ... A microscope on the Phoenix lander took images of dust and sand particles with the greatest resolution ever returned from another planet. The spacecraft’s optical microscope observed particles that had fallen onto an exposed surface, revealing grains as small as one-tenth the diameter of a human hair. ... Phoenix scientists confirmed the discovery of water ice on the Martian surface. The key new evidence was that chunks of bright material exposed by digging on June 15 and still present on June 16 had vaporized by June 19. ... The Ocean Surface Topography Mission/ Jason 2, a NASA–French space agency satellite, launched (far right) June 20 from Vandenberg Air Force Base on a globe-circling voyage to continue charting sea level, a vital indicator of global climate change. ... JPL launched the Global Climate Change website (<http://climate.jpl.nasa.gov>), providing easy-to-understand information about the causes and effects of climate change and how NASA studies it.

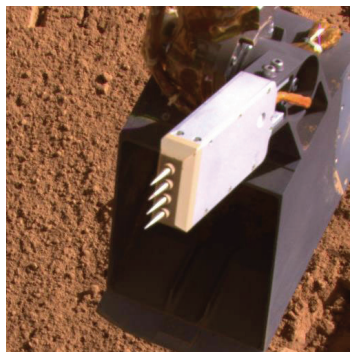
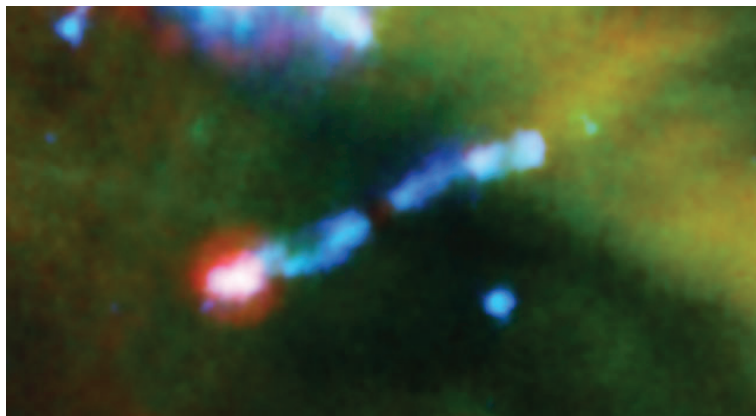
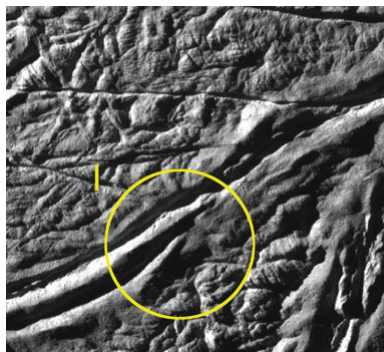
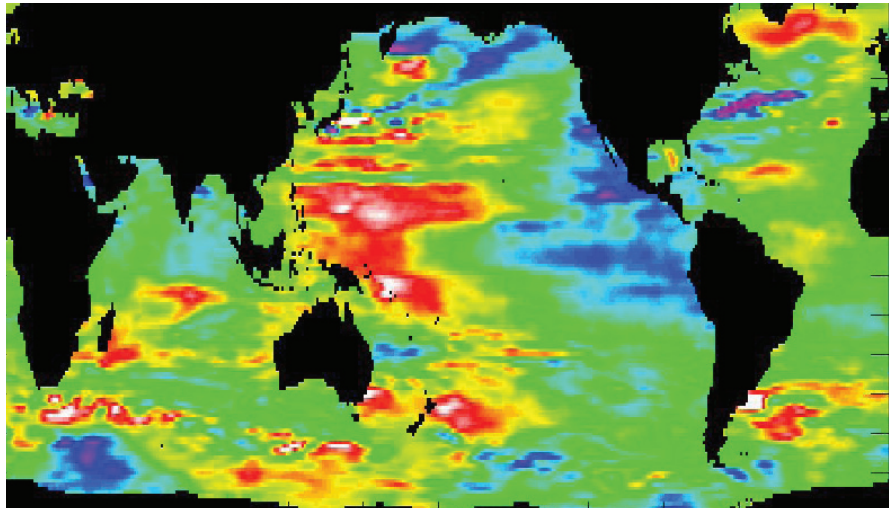


JULY

Observations from JPL’s Wide Field and Planetary Camera 2 on Hubble contributed to an image (below left) showing a delicate ribbon of gas floating eerily in space, a very thin section of a supernova remnant caused by a stellar explosion that occurred more than 1,000 years ago. ... Two studies based on data from Mars Reconnaissance Orbiter revealed that the Red Planet once hosted vast lakes, flowing rivers and a variety of other wet environments that had the potential to support life. One study, published in Nature, showed that vast regions of Mars’ ancient highlands contain clay minerals, which can form only in the presence of water. The data for the study derives from images (below right) taken by the imaging spectrometer and other instruments on the orbiter. ... A new sequence of Hubble Space Telescope images showed an unprecedented view of three red spots clustered together in Jupiter’s atmosphere. The three natural-color Jupiter images were made from data acquired in May, June and July 2008 by JPL’s Wide Field and Planetary Camera 2. ... Among the hardware taking images of Dolly (above right), which pounded the Gulf coast as a tropical storm and later as a hurricane, were the JPL-managed QuikScat satellite and the Atmospheric Infrared Sounder, an instrument onboard NASA’s Aqua satellite. ... Based on data from Cassini’s visual and mapping instrument, scientists concluded that at least one of the large lakes observed on Saturn’s moon Titan contains liquid hydrocarbons, and have positively identified the presence of ethane. This makes Titan (above left) the only body in our solar system beyond Earth known to have liquid on its surface. ... Laboratory tests aboard Phoenix identified water in a soil sample. “We’ve seen evidence for this water ice before in observations by the Mars Odyssey orbiter and in disappearing chunks observed by Phoenix last month, but this is the first time Martian water has been touched and tasted,” noted William Boynton of the University of Arizona, lead scientist for the Thermal and Evolved-Gas Analyzer. NASA also announced operational funding for the mission would extend through Sept. 30.

AUGUST

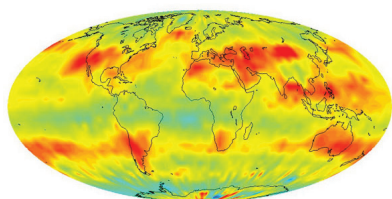
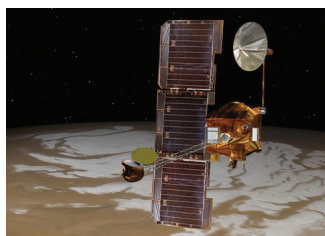
During its Aug. 11 flyby, Cassini pinpointed precisely where the icy jets erupt from the surface of Saturn's geologically active moon Enceladus. New carefully targeted pictures (below left) revealed exquisite details in the prominent south polar "tiger stripe" fractures from which the jets emanate, showing the fractures are about 300 meters (980 feet) deep. ... Mapping from the JPL-managed Jason 1 satellite showed that global sea level is on the rise, but the rise isn't uniform across the ocean. An image (right) shows white and red where sea level has risen the most; purple and blue where it has dropped. ... Phoenix took the first-ever image of a single particle of Mars' ubiquitous dust, using its atomic force microscope. The particle—shown at higher magnification than anything ever seen from another world—is a rounded particle about one micrometer, or one millionth of a meter, across. ... The Mars Exploration Rover Opportunity headed back out to the Red Planet's surrounding plains nearly a year after descending into the large Victoria Crater to examine exposed ancient rock layers (below right).



SEPTEMBER

A fork-like conductivity probe sensed humidity rising and falling beside Phoenix, but when stuck into the ground (below right), its measurements indicated soil that is thoroughly and perplexingly dry. ... The European Space Agency's comet-chasing satellite Rosetta flew by asteroid Steins in the main asteroid belt. A JPL microwave instrument onboard will measure the amounts of carbon monoxide, ammonia, methanol and oxygen leaving the comet, which will show how comet materials change from ice to gas and will help determine temperature changes as the comet approaches the sun. ... Cassini detected a faint, partial ring orbiting with one small moon of Saturn (below left), and confirmed the presence of another partial ring orbiting with a second moon, further evidence that most of the planet's small, inner moons orbit within partial or complete rings. ... Observations from Spitzer (above left) showed that water is being blasted to pieces by a young star's laser-like jets. The discovery provides a better understanding of how water—an essential ingredient for life as we know it—is processed in emerging solar systems. ... A laser instrument on Phoenix designed to gather knowledge of how the atmosphere and surface interact detected snow from clouds about 4 kilometers (2.5 miles) above the spacecraft's landing site. "Nothing like this view has ever been seen on Mars," said Jim Whiteway of York University, lead scientist for the Canadian-supplied meteorological station on the lander.

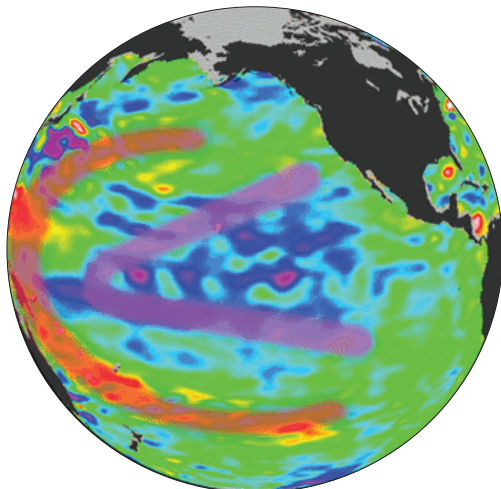
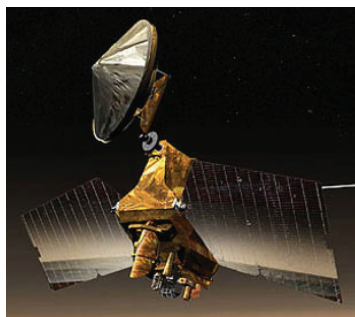
OCTOBER



Based on data from JPL's Atmospheric Infrared Sounder instrument on the Aqua spacecraft, a research team led by Moustafa Chahine of JPL published the first global satellite maps (below right) of the key greenhouse gas carbon dioxide in Earth's mid-troposphere, an area about 8 kilometers, or 5 miles, above Earth. The study reveals new information on how carbon dioxide, which directly contributes to climate change, is distributed in Earth's atmosphere and moves around the planet. ... Mars Odyssey (above left) underwent an orbit adjustment to allow its thermal emission imaging system to look down at sites when it's mid-afternoon, rather than late afternoon, allowing the science team to do much more sensitive detection and mapping of minerals. The mission was also extended through September 2010. ... JPL engineer Jon Giorgini received the American Astronomical Society's prestigious Harold Masursky Award for JPL's Horizons system, an online database that can generate locations and orbits for the almost half-million known celestial bodies in our solar system. The award recognizes outstanding service to planetary science and exploration. ... Phoenix was honored with a Breakthrough Award by Popular Mechanics magazine. Project Manager Barry Goldstein of JPL, principal investigator Peter Smith of the University of Arizona, and Ed Sedivy, the Phoenix program manager at Lockheed Martin Space Systems in Denver, were recognized for their mission leadership. Phoenix also received honors from the National Space Club (below left), which bestowed its Astronautics Engineer Award to the team for its significant contributions. ... JPL scientists, satellites and ground-based instruments contributed to a month-long, university-led experiment on Hawaii's Mauna Loa volcano to track water vapor in Earth's sub-tropics, which affects global temperatures, and rainfall in North America. ... JPL's Moon Mineralogy Mapper, one of two NASA instruments, is carried aboard India's maiden moon voyage, Chandrayaan 1, which launched Oct. 21 (above right). The instrument will survey the lunar surface's mineral resources.

NOVEMBER

Phoenix ceased communications after operating for more than five months. As anticipated, seasonal decline in sunshine at the robot's landing site was not providing enough sunlight for the solar arrays to collect enough power to charge batteries that operate the lander's instruments. Engineers last received a signal from the lander on Nov. 2. ... Phoenix won recognition from Popular Science magazine as an innovation worthy of the publication's "Best of What's New" Grand Award in the aviation and space category. ... JPL's QuikScat mission team was recognized for helping scientists better understand our home planet with the presentation of the William T. Pecora Award by NASA and the U.S. Department of the Interior. The two agencies present individual and group Pecora awards annually to honor outstanding contributions in the field of remote sensing and its application to understanding Earth. ... JPL's Wide Field and Planetary Camera 2 onboard Hubble contributed to a new portrait (right) of one of the universe's most brilliant star-making galaxies. ... Mars Reconnaissance Orbiter revealed vast Martian glaciers of water ice under protective blankets of rocky debris at much lower latitudes than any ice previously identified on the Red Planet. Scientists said buried glaciers extend for dozens of miles from edges of mountains or cliffs. A layer of rocky debris blanketing the ice may have preserved the underground glaciers as remnants from an ice sheet that covered middle latitudes during a past ice age. This discovery is similar to massive ice glaciers that have been detected under rocky coverings in Antarctica. ... The Dawn spacecraft shut down its ion propulsion system as scheduled and continued toward a Mars flyby in February 2009 for a gravity assist to help get to asteroid Vesta.



DECEMBER

The launch of Mars Science Laboratory, originally scheduled for fall 2009, was rescheduled to fall 2011. The mission will send a next-generation rover with unprecedented research tools to study the early environmental history of Mars. ... The latest image of sea-surface height measurements (right) from the U.S./French Jason 1 oceanography satellite shows the Pacific Ocean remains locked in a strong, cool phase of the Pacific Decadal Oscillation, a large, long-lived pattern of climate variability in the Pacific associated with a general cooling of Pacific waters. The image also confirms that El Niño and La Niña remain absent from the tropical Pacific. ... Mars Reconnaissance Orbiter (left) completed its primary, two-year science phase. The spacecraft found signs of a complex Martian history of climate change that produced a diversity of past watery environments.

Events celebrate rovers' five years

Numerous events have been planned for January to celebrate the five-year anniversary of JPL's Mars Exploration Rovers, which landed in separate areas of the Red Planet in January 2004.

The tentative schedule includes showings of the Norman Seeff-pro-

duced documentary "Triumph of the Dream" on Tuesday, Jan. 6 and Friday, Jan. 9 from 11:30 a.m. to 1:30 p.m. in von Kármán.

The Lab's popular von Kármán Lecture Series will feature Mars Exploration Rovers talks Thursday, Jan. 16 at Caltech and Friday, Jan. 17 at Pasadena City College. Rover principal investigator Steve Squyres will lecture Thursday, while Project Manager John

Callas will handle Friday's talk at PCC. Both lectures start at 7 p.m.

The National Geographic Channel documentary "Five Years on Mars," which uses photo-realistic animation based on the rovers' own photos and features several of the twins' drivers, will be shown Wednesday, Jan. 21 in von Kármán. And the Griffith Observatory in Los Angeles is scheduled to host talks by Callas and Mars Public

Engagement Office team members on Friday, Jan. 23 at 7 p.m.; Saturday, Jan. 24 at 1:30, 4:30 and 7 p.m.; and Sunday, Jan. 25 at 1:30 and 4 p.m.

Also planned is a JPL/Planetary Society collaboration for a program to be determined at the Boston Court Theater in Pasadena, near Old Town.

For an updated schedule of events, visit <http://dailyplanet>.

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Continued from page 2

with the budget that at one time he thought he had.

WHAT CAN YOU SAY ABOUT THE MSL LAUNCH DELAY?

Landing on Mars is among the hardest things that NASA does. And MSL is one of the most complex robotic missions that NASA has ever undertaken. We tried our best to get it ready for 2009 but fell short. When it became clear that launching

in 2009 would entail risks that exceed acceptable thresholds for a flagship mission, JPL and NASA decided to delay it to the 2011 opportunity.

OVERALL, HOW DO YOU JUDGE THE PROGRAM'S ACCOMPLISHMENTS OF THE PAST DECADE?

During this decade, five successful missions in a row—two orbiters and three landers—have been launched to Mars. They have not only been engineering successes, but scien-

tific triumphs as well. I have observed the delight and sheer giddiness of scientists as hundreds of thousands of images and billions of bytes of data have showered down on them, and have been captured in hundreds of scientific articles and books revealing a Mars we never knew. Kids everywhere follow the saga of Spirit and Opportunity. From the time they bounced their way onto the surface of Mars, they have become symbols of American capability.

HAS IT ALL BEEN WORTH IT?

Has Hubble Space Telescope been worth it even though it overran its development budget? Or Spirit and Opportunity? Or NASA's Cosmic Background Explorer that won its principal investigator the Nobel Prize but went over budget? I am not impartial, but both in terms of its engineering and science capabilities MSL has the potential to be a similarly seminal mission when we look back in a few years.



Steven Ostro

Passings

Steven Ostro, 62, an astronomer renowned for his groundbreaking work in asteroid and satellite radar studies, died Dec. 15.

Ostro was an assistant professor of astronomy at Cornell University prior to joining JPL in 1984, where he established the radar astronomy group. He became a JPL senior research scientist in 1992 and was a member of the Cassini Titan radar mapper team. His seminal work on the surface properties of the Galilean satellites led to the development of new models to explain how electromagnetic radiation interacts with ice.

Among Ostro's awards and honors are the Gerard P. Kuiper Prize from the Division for Planetary Sciences of the American Astronomical Society in 2003 and NASA Medals for Exceptional Scientific Achievement in 1991 and 2004, in both cases for his leadership of asteroid radar astronomers as well as his scientific accomplishments. Also, the asteroid 3169 Ostro is named in his honor.

Ostro is survived by his wife, Jeanne, and three children.

Edward Sheldon, 91, a retired section manager and member of the technical staff, died June 24.

Sheldon joined JPL in 1951. Among his work was the development and management of environmental test facilities uses in the planetary exploration program, as well as energy and technology applications. He retired in 1978.

Sheldon is survived by son Ed III and daughter Julia. Services were held in Bonita, Calif.

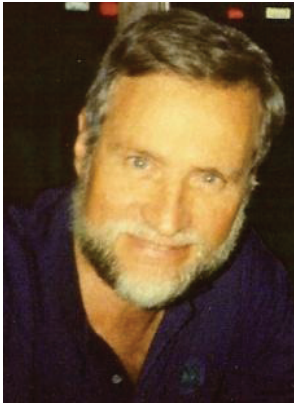
Retiree **James Cramer**, 86, died Sept. 26.

Cramer worked at the Lab from 1972

to 1988. He is survived by sons Dennis, Paul and Mark and daughter Kelly.

Sally Hampton, a former JPL telecommunications operator, died Oct. 21.

Hampton left JPL to join Caltech, where she worked as telephone room supervisor from 1978 to 1996.



John Pensinger

John Pensinger, 73, a retired engineer, died Oct. 23.

Pensinger had two tenures at JPL, first from 1968 to 1976, when he served as technical group supervisor for the Viking spacecraft Data Storage Group and worked on data-handling software for the Viking, Voyager and Mariner '71 missions. During his second tenure from 1994 to 2007 he served in Rome as contract technical manager and European representative for Cassini's high-gain antenna. At JPL, he managed the Low Temperature Microgravity Physics Facility.

He is survived by his wife, Kathie; daughters Joanna, Joy, Julie, Jeanine and Faith; and sons Carlos, John and James; 25 grandchildren and five great grandchildren.

Services were held Nov. 1 at Calvary Chapel in Murietta, Calif.

Pamela O'Brien, 65, a retired senior accountant, died Nov. 10.

O'Brien worked at JPL from 1970 to 1999. She is survived by her husband, Victor; son Gerald; daughter Catherine; and grandchildren Catherine and Rebecca. Services were held at Forest Lawn in Covina.



Gordon Wood

Gordon Wood, 64, a retired technical section manager and member of the technical staff, died Nov. 25.

Wood joined the Lab in 1967 and retired in 1999. He built radios and ultra-stable oscillators for spacecraft that flew to Mars and the outer planets. He managed an experimental deep-space tracking station in the Mojave Desert, managed JPL's Telecommunications Systems organization (339) and was responsible for communications with the Sojourner Mars rover. He received two NASA Exceptional Service Medals, and a Caltech/JPL award for technical excellence.

Wood is survived by his sister Carol and his aunt Olive; many cousins, nieces and nephews; and partner Glenn E. Cunningham. Burial was in Three Rivers, Calif.

Letters

I would like to thank my JPL colleagues and Section 173 for their

condolence messages on the recent passing of my mother. Thanks also to JPL for the beautiful plant. My mother was a very special person. Through her extraordinary efforts and perseverance, she succeeded in keeping my brother and me alive during the Holocaust. My only regret is that she passed away before I completed the translation of her World War II memoirs, which will soon be published in English.

Harold Minuskin

My family and I thank everyone who supported us after the passing of my mother, Fern Livermore. My mother always appreciated JPL and the work that we do. We appreciate all of the notes and flowers, and thanks to JPL for the lovely plant.

Tom and Elaine Livermore

Thank you so much to all my friends and colleagues for their kindness during the time leading up to and following the passing of my mother. Also, my appreciation to JPL's IT services for their incredibly responsive help getting remote access services set up so that I could be with my family during that difficult time. And finally, thank you to the ERC for the lovely plant in memory of my mom.

Lynne Cooper

Retirees

The following JPL employees retired in December:

Timothy Thompson, 24 years, Section 3266; **Edward Doudian**, 13 years, Section 388L.

The following employees retired in January:

Yolanda Walton, 39 years, Section 501; **Kumar Chandra**, 28 years, Section 335J; **Noel Alejandrino**, 12 years, Section 2126.

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JPL RETIREES:
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