Jet Propulsion Laboratory

Universe

JULY
2012
VOLUME 42
NUMBER 7

‘Ten years for seven minutes’

Entry, descent and landing team readies Curiosity for a historic pinpoint dive

By Mark Whalen

Just about everything on JPL’s Mars Science Laboratory is new, the first-of-its-type. As the Laboratory anxiously awaits the Aug. 5 landing of the Curiosity rover, MSL’s entry, descent and landing team is executing a new way to get to the surface of Mars.

A little help from the old ways of doing business is helping too. Using an entry and guidance system adapted from NASA’s Apollo missions of the 1960s and 1970s, the team will fly the spacecraft like a wing as it hurtles through the upper atmosphere.

After a seven-minute descent during which the rover will go from 13,000 mph to zero, aided by a revolutionary skycrane landing system, Curiosity will begin a two-year study of whether Gale Crater ever offered an environment favorable for microbial life.

“I don’t know if people realize this, but capsules like Apollo and Gemini, when they came in, had this angle of attack—a center of mass offset that allows just a little bit of lift,” said Allen Chen, the team’s operations and flight dynamics lead and the voice of mission control on landing day. “So instead of the nose flying straight into the flow, it’s actually tipped a little, providing a bit of lift in the direction away from where the nose is pointed.”

The lift capability has proven critical in a couple of respects for the mission. Chen said it allows bringing to Mars a lot more mass than any previous attempt, and that the size of MSL’s landing ellipse in Gale Crater can be reduced significantly. The mission recently trimmed the ellipse from 25 × 20 kilometers to 19 × 7 kilometers.

“Compared to other missions, we have the ability to land near something we want to go to, and drive to it,” said Chen. “Previously, because landing ellipses were so large compared to the driving capability of the rover, you pretty much had to land on what you were looking for.”

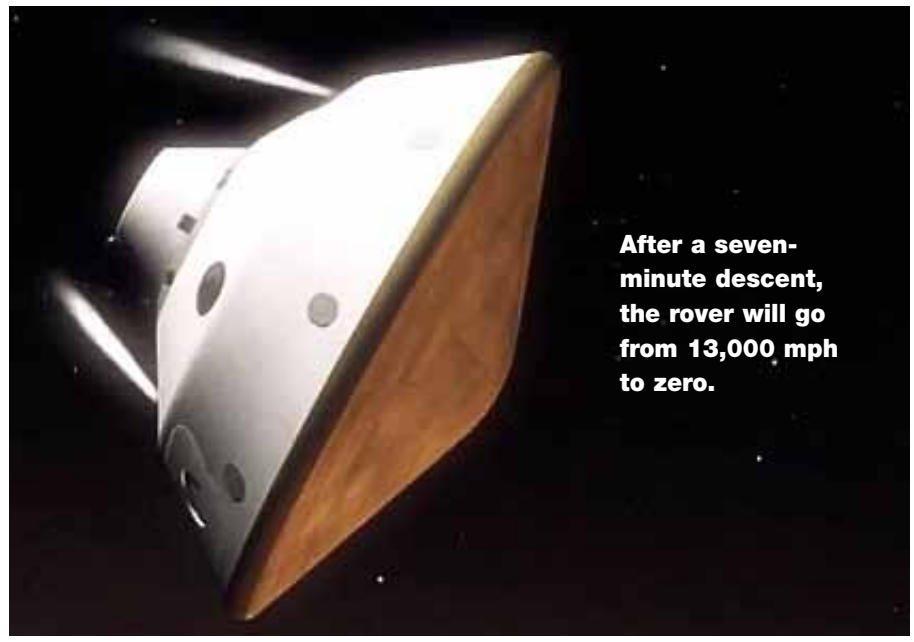
He estimated that moving the ellipse about 7 kilometers closer to the science target would save about four months of Curiosity’s drive time.

“Also, with Mars Reconnaissance Orbiter taking pictures of the landing site, considering the size of our rover, we can almost see every rock that’s a danger to us. It’s an advantage previous missions didn’t have.”

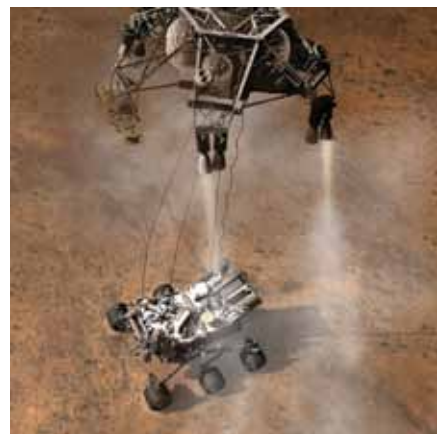
Chen noted another reason—beyond guided entry—why Curiosity’s landing ellipse is so small relative to past missions. “We know more about Mars now,” he said. “We have orbiters looking at the atmosphere, which we’ve also been modeling. “We probably have a better idea of what Mars is going to look like than ever before.”

Mars Reconnaissance Orbiter imagery will also aid in determining the need for adjustments. Chen said the team has the capability to make changes on the vehicle up to about two hours before landing, scheduled for approximately 10:31 p.m. Pacific time Aug. 5.

“In extreme cases, if a storm were to build up around the site, then we might do something different. However, the guided entry makes us resilient to issues in the atmosphere. Also, since Gale is so low, there’s a lot of margin built into the system to deal with bad conditions. So if we see a storm, we may choose to adjust something, we may choose not to. But we’re watching, just in case.”



After a seven-minute descent, the rover will go from 13,000 mph to zero.



Top: Artist’s concept of the guided entry of Mars Science Laboratory through the atmosphere. Bottom: Curiosity on approach; the mission’s skycrane landing system.

Chen, who has worked on different facets of the mission for almost 10 years, including the last nine on EDL, noted that data from past missions—particularly Viking, including how the vehicle was designed and how it flew—proved invaluable.

“We’re standing on the shoulders of giants,” he said. “Being the first ones there, the Viking crew didn’t know much about Mars; they wanted to make sure they had done everything in their EDL sequence, as soon as possible, because they didn’t know how high the ground was relative to where they were landing.

“Producing a quality Viking-level documentation would be unusual to do here, but it’s something we should do this time out, because it could be that it might be another decade before we get a chance again,” Chen added. “We learned a lot of things on this mission; it would be a shame to lose those and have people start all over again next time.”

Chen said he was very much into astronomy as a kid, “but it turns out I’m better at engineering than science,” he said. “That’s why I’m here.”

He recalled his history on the mission—and the bottom line—with a chuckle. “I’ve seen many different versions of MSL; there’s very little on this project that I haven’t at least tried,” he said, noting his involvement in payload, testing and concept development before the coming plunge. “Ten years for seven minutes.”

Science fiction reality check

By Mark Whalen

Photo by Dan Goods / JPL

Much of what you'll see in science fiction films is unbelievable, if not physically impossible. In the case of the currently screening deep-space thriller *Prometheus*, director Ridley Scott turned to JPLer Kevin Hand for help in—as much as possible—keeping it real.

Hand, deputy chief scientist for solar system exploration, offered advice to filmmakers when the film was still at the script stage. He takes satisfaction knowing that his counsel made an impact on the film, set many decades in the future.

"In Prometheus you'll see discussions of a moon that's habitable, discussions of the atmospheric composition of this new world; you'll see cool technologies that are derived from technologies that have been developed here at JPL or other parts of NASA," said Hand. "It's good to enjoy the small victories when you're trying to get science well represented in TV and film."

Hand said filmmakers wanted to explore the prospect for life beyond Earth. He offered what's known about habitable environments in our solar system, the surface of Mars, the oceans of Europa and Enceladus, the bizarre chemistry of Titan. "Then we went further out and explored what we know about planets around other stars, the exoplanets," he said.

They definitely utilized a lot of that information. The astronauts in the film go to a world that was based on the Kepler mission; the original story had it as a habitable planet, but after Hand's discussion about moons being potentially habitable places, they decided to make the astronauts' new world a moon of a massive gas giant.

"I'm excited about that," Hand said. "Most people, when they think of the search for life elsewhere, think about planets, not moons."

Hand noted that the creative process for writers, directors and creative teams parallels that of how JPLers explore ideas with much greater constraints, with the realities of science, math and physics factoring in. "It's somewhat easy for us as scientists and engineers to get a bit of tunnel vision, and working with people who think about exploration, discovery and science—in an artistic context—helps bring me out of that," he said. "To some extent the creative process in working on these projects has helped keep my creative juices flowing."

Hand's other movie consults include *Avatar, Thor* and a film called *The Europa Project*, due out later this year. He is a member of the Science and Entertainment Exchange, an organization run by the National Academy of Sciences that promotes more science into movies and TV.

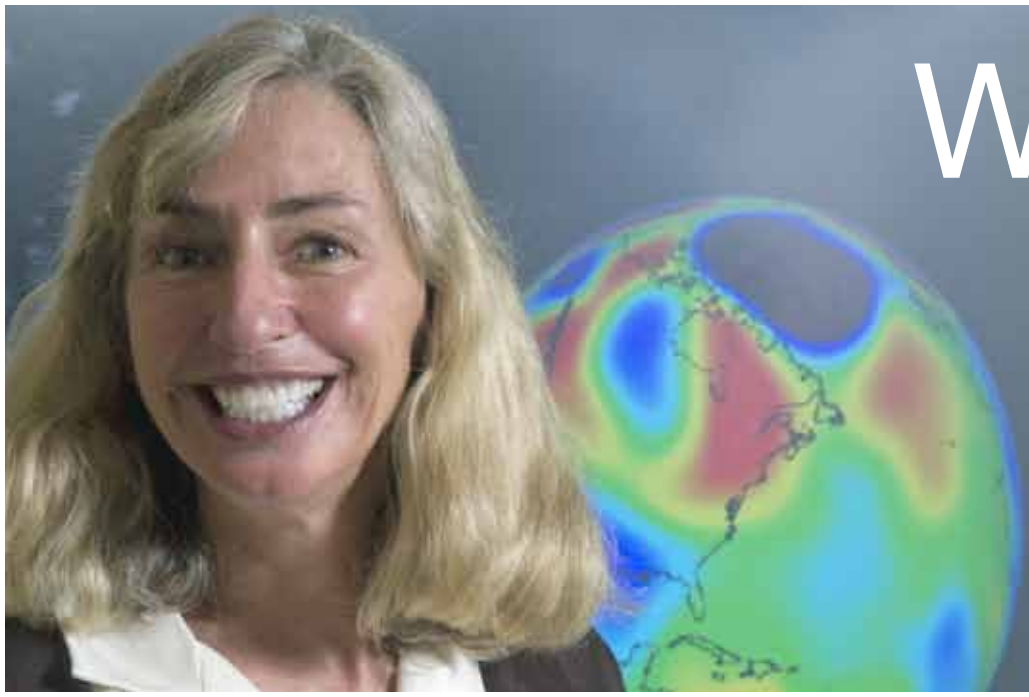
"What excites me about films like *Avatar, Prometheus* and the Europa film is that they're great venues for pushing concepts and ideas, and it's our job—on a day-to-day basis—to at least make steps toward that reality with the missions we're flying and the experiments we're doing," Hand said.

"Someday I hope that the scientific consciousness of the public will be advanced enough by these exciting ideas that we will get these missions to Europa, Enceladus, Titan and Mars. It's really only through the interest and engagement of the public, which is paying $10 a pop to watch these movies, that will get these missions off the ground."

Open 2012 House

More than 38,000 visitors attended the Lab's annual Open House on June 9-10. Among the popular attractions was "The Voyage" (right), a new mobile phone scavenger hunt that attracted about 5,000 participants.

Photos by Brad Graverson



What on Earth is going on?

Universe caught up with Earth Science and Technology Director Diane Evans for a discussion on the status and contributions of JPL's Earth science initiatives

q&a

By Mark Whalen

Thom Wynne / JPL Photo Lab

What's in the pipeline for the near future?

We are really busy in the directorate now. In addition to keeping our 12 current flight experiments operating, we're preparing for three launches in 2014.

The current schedule calls for launching Orbiting Carbon Observatory-2 no earlier than July 2014; an Oct. 31 launch for the Soil Moisture Active Passive mission, which will help us to better understand Earth's water, carbon and energy cycles; then a Dec. 3 launch for Jason-3, a follow-on to Jason-2 we're conducting with the National Oceanic and Atmospheric Administration and our European partners.

Kennedy Space Center is evaluating launch vehicle proposals for all three of our missions, and by early July we should know which have been selected.

The OCO-2 instrument is currently undergoing assembly, test and launch operations. The data from the most recent thermal vacuum tests last month are fantastic. The scientists couldn't be happier. It's a much better instrument than the original OCO.

The instrument team is also focusing its attention on OCO-3, which will fly on the International Space Station. There will be small changes to the instrument, but it's generally the same design. We have to add some capability because we won't have the freedom to gimbal the whole spacecraft as we would usually do on a satellite.

What are the effects on Earth science in the NASA FY 13 budget request?

The most recent decadal survey for Earth science recommended a budget of what was needed for Earth observations to be at a healthy place, and the president's FY 2011 budget came close to that, projecting forward. There is a modest increase in FY 12 and we do expect a modest increase in FY 13 as well.

What's on the horizon long-term?

In formulation are the Surface Water and Ocean Topography mission, a pre–phase A concept targeted for a FY 2019 launch, and a GRACE follow-on mission, targeted for launch in 2017.

Also, we're continuing formulation of the L-band radar portion of the Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI). The plan is to pursue this effort in partnership with India. It's JPL's challenge to fit the mission in the cost cap and still meet a 2019–2020 launch date.

Most likely we will be developing the instrument payload in-house at JPL and look to our partners for spacecraft and launch contributions.

What's the importance of your organization's support of non-NASA sponsors?

The 2007 Earth science decadal survey made it clear the emphasis on observations was changing from pure research to applications and societal benefits. Subsequently, with more interest in climate change and population growth, a lot of environmental issues require critical data.

So we set up the Global Change and Energy Office to work with JPL's National Space Technology Applications Office, under the direction of Bob Cox, to transition research into results that are helpful for policy makers.

A lot of the operational agencies use traditional data-gathering methods for things such as snow surveys. But we're showing them how they can acquire more accurate information by using some of the new remote-sensing techniques from satellites or aircraft.

How do you measure success, in terms of JPL providing critical climate-change data without advocating solutions?

That's actually the part I'm really enjoying. The observations speak for themselves. What people do to interpret them is separate.

This is where the JPL Center for Climate Science comes to the fore. Graeme Stephens, Joao Teixeira and Duane Waliser—in particular—have gotten JPL involved with the next assessment of the Intergovernmental Panel on Climate Change. Their last report, in 2007, contained very little satellite data, although GRACE, which showed that ice sheets were losing mass, was a huge breakthrough that satellites enabled.

We're hoping to have a major impact on model assessment and improvement. That's a key element of the Center for Climate Science—getting correct information into the right hands. If the models you're using to project forward aren't good, you could be planning for the wrong future.

One of our biggest upcoming challenges will be water resources. The models don't even agree on which areas in the world are going to have more or less precipitation—that's crazy. So we need to find a way to bridge the general circulation models to what's really happening in a regional area, so that people can make decisions for a year or six months from now.

That will be hugely impactful. Everyone's familiar with the 1997 El Niño and how that was so clearly brought home with TOPEX/Poseidon altimeter data.

So we're getting there. We're starting to see things that lead us to believe we can forecast things on different scales than we currently can, to contribute to observing a "whole Earth system."

A senior researcher on carbon and ecosystems will join the Center for Climate Sciences in October. Also, water-cycle science will be moved into a more applied area of water-resource management. With SMAP coming up in two years and SWOT in the FY 2019 timeframe, we would like to hire more in this area.

How has this renewed activity in Earth studies changed JPL?

A lot of people are realizing that what we do is really exciting and worth a second look. We go from component technology to building aircraft instruments to flying them—the whole end-to-end. It all starts with our technological capability—partnered with JPL's systems engineering and science expertise.

With the support of the Earth Science Technology Office at NASA Headquarters, today we have much more work in instrument development. We've shown that we can successfully nurture technologies from the concept, through research and development, into a small technology task funded by NASA, and then into a mission. In my mind that might be something that people haven't appreciated—that it takes a long time to go through that cycle, but if you have a good idea it will be developed and it will eventually fly.

Every 18 months there will be an announcement of opportunity for a new instrument; that's why our research and technology development initiative next year will focus on instruments. To me, this is where we get the excitement and the synergy between scientists and engineers—at the instrument level.

JPLers have proven that Earth missions are equally challenging and exciting, in terms of the engineering and the technology that you put to work. It is our good performance on the jobs we've had that will sustain us. When the decision was made on which decadal survey mission was going to go first, it was SMAP. That was 100 percent based on the performance that people had done, well before my time.

News Briefs

NuSTAR on black-hole search

JPL's Nuclear Spectroscopic Telescope Array (NuSTAR) launched June 13 to begin its two-year mission to unveil secrets of buried black holes and other exotic objects.

The observatory began its journey aboard an L-1011 "Stargazer" aircraft, operated by Orbital Sciences Corp. NuSTAR was perched atop Orbital's Pegasus XL rocket, both of which were strapped to the belly of the Stargazer plane, which departed from Kwajalein Atoll in the central Pacific Ocean.

NuSTAR will use a unique set of eyes to see the highest energy X-ray light from the cosmos. The observatory can see through gas and dust to reveal black holes lurking in our Milky Way galaxy, as well as those hidden in the hearts of faraway galaxies.

NuSTAR is a Small Explorer mission led by Caltech. For more information, visit *http://www.nasa.gov/nustar*.

Honors for Mars orbiter team

JPL's Mars Reconnaissance Orbiter team has been awarded the National Space Society's 2012 Space Pioneer Award in the Science and Engineering category.

The honor extends to all of the mission team, including construction of the spacecraft and its instruments, mission operations, data reception, and analysis. It was bestowed at the International Space Development Conference in Washington, DC in May.

For more information, visit *http://isdc.nss.org/2012*.

Earth science technology proposals selected

Six JPL researchers have been awarded funding for their proposals to NASA's Earth Science Technology Office Advanced Information Systems Technology program.

Amy Braverman of the Science Data Understanding Group will lead "Multivariate Data Fusion and Uncertainty Quantification for Remote Sensing." The goal is to develop statistical methods for fusing data from heterogeneous remote-sensing data sets to infer underlying geophysical fields, and produce associated uncertainties. This technology exploits the strengths of multiple instruments to produce more complete fused data sets with lower uncertainties than is possible using traditional methods.

Andrea Donnellan of the Science Division will lead the "QuakeSim: Multi-Source Synergistic Data Intensive Computing for Earth Science" project. The goal is to develop a multi-source, synergistic, data-intensive cloud computing system to model complex interacting earthquake fault systems. The primary focus is to extend existing QuakeSim infrastructure to support fault modeling with a focus toward quake forecasting and response.

Svetla Hristova-Veleva of the Radar Science and Engineering Group will lead "Fusion of Hurricane Models and Observations: Developing the Technology to Improve the Forecasts," which will build upon two NASA-funded projects, the JPL Tropical Cyclone Information System and the Instrument Simulator Suite for Atmospheric Remote Sensing.

Hook Hua of the High Capability Computing and Modeling Group will lead "Advanced Rapid Imaging and Analysis for Monitoring Hazards" to develop an advanced cloud service–oriented science data system for automating geodetic data processing and data product generation for rapid response to natural hazards.

Paula Pingree of the Flight Instrument Electronics and Small Satellite Technology Group will lead "On-Board Processing to Advance the PanFTS Imaging System for GEO-CAPE." The major challenge is to achieve at least 20× magnitude reduction in data rate by converting time-domain interferograms to spectra with a highly parallel instrument digital signal processing design and demonstrate the capability in a field test to validate a technology readiness level of 5.

Simone Tanelli of the Radar Science Group will lead the development of the Unified Simulator for Earth Remote Sensing, a modeling tool to generate simulated measurements by spaceborne platforms in a unified and self-consistent manner. The architecture will facilitate development and validation of new modeling tools and retrieval algorithms; assess current, future and hypothetical missions; and will support implementation of more comprehensive collaborative architectures for analysis and development of products generated by Earth science remote sensing missions.

Study to assess urban changes

Son Nghiem of the Radar Science and Engineering Group has been named principal investigator for a recently accepted proposal in response to a NASA solicitation for the agency's Interdisciplinary Research in Earth Science program.

Nghiem will lead "Mega Urban Changes and Impacts in the Decade of the 2000s," which will investigate the impacts of urban changes on the environment during the previous decade's unprecedented growth of large cities.

The research proposes to study urban heat islands, urban domes, greenhouse gas emissions, pollution in atmosphere and water systems, and other environmental changes. Using decadal data from multiple satellites—including several managed by JPL—the study will compare rates of urban change with rates of change of pollution, temperature change, and demographic and socioeconomic factors. The research includes major cities in Asia, Europe, the Americas and Africa.

JPLers on DESDynI-R team

Two JPL researchers have been selected for a science definition team to support the radar component of the Deformation, Ecosystem Structure, and Dynamics of Ice–Radar (DESDynI-R) mission, which is in pre-formulation.

NASA selected 15 of 38 proposals submitted for the science definition team opportunity.

Benjamin Holt of the Oceans and Ice Group will lead a study that proposes to characterize and define the mission's science requirements for deriving sea-ice velocity. This will contribute to the continuation of the record of high-resolution sea-ice observations of the Arctic Ocean, including velocity, and the beginning of such records in the southern ocean.

The team has defined sea-ice science requirements for multiple Earth science missions and tasks. Its expertise includes the use of synthetic aperture radar, radar and lidar for deriving geophysical sea-ice parameters including deformation, thickness, type and in processes related to heat exchange and ocean–ice interactions.

Sassan Saatchi of the Radar Science Group will lead a study on the development of models to assess performance of DESDynI-R in mapping changes of forest cover and aboveground biomass.

Through the use of existing airborne and spaceborne data, the study proposes to develop requirements for the mission's radar polarimetric and potentially tandem interferometric observations. The team will develop performance models to examine how well DESDynI in its new configuration can meet its main ecosystem science objectives.

Proposal to target east Africa

Stephanie Granger of the AIRS Atmospheric Science Group will lead a study funded by the NASA Earth Science Division's Applied Sciences Program. It will support Servir, a system sponsored by NASA and the U.S. Agency of International Development that integrates satellite observations, ground-based data and models to monitor and forecast environmental changes and to improve response to natural disasters.

Granger is principal investigator for "East Africa Drought and Agricultural Productivity Assessment and Prediction System," which proposes to provide drought assessments and probability maps, as well as associated maps of agricultural productivity and yield.

The team's drought assessment and prediction method, called the Regional Hydrological Extremes Assessment System, has a proven hydrologic model at its core coupled with an existing agricultural productivity model.

Faramaz Davarian

JPL spotlighted in institute's centennial document

Faramaz Davarian, manager of the Deep Space Network Advanced Engineering Program, along with other JPL authors, contributed to the recently published centennial issue of the *Proceedings of the Institute of Electrical and Electronics Engineers*.

Davarian's article is a prolog to the publication's Space Exploration and Science section, which also includes a comprehensive story on the development of science, surveillance and commerce in space. This multi-author article includes the perspectives of JPL historian Erik Conway and Innovation Foundry manager Brent Sherwood.

Passings

Walter Higa, 92, retired from the Deep Space Network, died April 8.

Higa worked at JPL from 1954 to 1979. He led the team that developed masers for low-noise amplification and later served as team leader of the New Circuits Elements and Microwave Electronics groups. His work included the design and development of hydrogen-maser frequency standards, liquid-helium dewars, and closed-cycle helium refrigerators to cool traveling-wave masers to 4 kelvins. He continued to consult for JPL for several years after retirement.

Higa is survived by children Lani Higa Reinhart, Noel Higa, Craig Higa and their spouses; grandchildren Will Reinhart, Lily Reinhart Arfa, Tasha Higa Branch, Marshall Higa, Jimmy Higa and Kerin Higa; and seven great-grandchildren.

Eric Rhinehart, 46, a systems analyst in the Product Lifecycle Management Enterprise System Analysis Group of the OCIO, died May 27.

Rhinehart, who had joined JPL in 2000 in the Mechanical Fabrication Shop, was the product and development lead for the JPL Electronic Mail System application and a recipient of a NASA Honor Award in 2008.

He is survived by his wife, Lorraine, and children Michael, Alex, Jade and Amber. Services were held June 9 at Claremont Baseline Community Church. A memorial fund has been set up for the Rhinehart family at the Caltech Credit Union, account #1072638.

Barbara Bowman, 64, staff to executive management in the Office of Safety and Mission Success Directorate, died June 6.

Barbara Bowman

Bowman joined the Lab in 1998 and had worked in the OSMS directorate office since 2002. Previously, she was a JPL contractor for 13 years.

She is survived by her husband, Don; mother Letha Shields and sister Debbie Andera of Gardner, Kansas; sister Carole Sebits of Santa Barbara; as well as several nieces.

Bowman's family requests that consideration of donations in her memory be sent to Kaiser Hospice, 3699 Wilshire Blvd., 3rd floor, Los Angeles, CA 90010. A celebration of her life will be held at a date and time in July to be announced later.

Letters

Thank you, JPL and DSN friends, for the lovely plant from Eiji's. Your thoughtfulness is comforting and greatly appreciated. Our best regards,
Bill and Olivia Tyler

Retirees

The following employees retired in June: **Sharon Valentine**, 36 years, Section 9040; **Colleen Miyahara**, 31 years, Section 2127; **John Crawford**, 27 years, Section 3120; **Brindley McGowan**, 11 years, Section 1173.

Universe

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Design
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Production
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Photography
JPL Photo Lab

Universe is published by the Office of Communications and Education of the Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109.