

Dawn ready to explore a second new world | By Mark Whalen

After 13 months at asteroid Vesta, spacecraft is on its way toward protoplanet Ceres

This mosaic synthesizes some of Dawn's best views of the giant asteroid Vesta. The towering mountain at the south pole—more than twice the height of Mount Everest—is visible at the bottom of the image. The set of three craters known as the "snowman" can be seen at the top left.

The Dawn spacecraft's past year of observing Vesta has returned memorable views of a rocky, pitted landscape that scientists say resembles a small planet more than a typical asteroid.

Dawn has begun a two-and-a-half-year cruise to protoplanet Ceres. That body will undergo six months of observation once Dawn arrives in February 2015.

Not only is Dawn the first spacecraft to orbit an object in the main asteroid belt, it's the only one ever to plan to orbit two different destinations.

"We exceeded our objectives in every area," said Mission Manager Marc Rayman. "Things not only went better than expected, they were even better than I had hoped."

At launch in 2007, plans called for Dawn to spend seven or eight months at Vesta. However, about two years into the cruise phase, the team determined that more power could be devoted to Dawn's ion propulsion system, and hence greater thrust. This allowed the spacecraft to be able to spend a full year there.

"All of that extra time was exceedingly productive," said Rayman. "We were taking additional data with all instruments in all investigations, adding to what was already a fabulous bounty."

NASA earlier this year approved an additional 40 days for Dawn at Vesta, making the total stay about 13 months while still allowing the mission to keep its appointment with Ceres in 2015.

Carol Raymond, Dawn's deputy principal investigator, expected a fairly generic, regolith-covered body when the spacecraft was making its way to Vesta. "I didn't want to get my hopes up that there would be fantastically interesting things to see," she said. But as Dawn got nearer, her outlook changed noticeably.

"When we first saw Vesta, it was very startling, even upon approach," Raymond said. "To see the brightness contrasts—indicating strong variation in the material properties of the surface—then to see the very large-scale tectonic features and the complexity of the south

polar region due to large impacts, was a very exciting surprise.

"It certainly exceeded my expectations," she added. "The remarkable thing is that although we hadn't visited, we knew a lot about Vesta before we got there. But that still didn't conjure up the kind of fantastic complexity of compositional diversity, of geological processing and the landforms that we found."

Indeed, Dawn exposed extreme topography, the second tallest mountain now known in the solar system, a 500-kilometer-wide impact basin that's close to the diameter of Vesta, and a vast system of equatorial troughs.

What can top this? To do it all again—this time at a new target.

On to Ceres. Project Manager Bob Mase noted the new set of challenges for the team as Dawn travels to a second unseen world.

"We are already beginning to plan the types of operations strategies that we want to employ for the Ceres science campaign," Mase said, adding that it might take almost a year to finalize high-level architecture and details.

"One obvious benefit we'll have at Ceres is the very successful experience at Vesta," Rayman noted. "It's going to be a lot easier getting ready for Ceres, knowing what worked well and not so well at Vesta. There's nothing like real experience; it's the best educator."

The Dawn science team will remain quite busy during the cruise to Ceres, according to Raymond. "We will be looking at Vesta data for most of the next year," she said.

"We saw a lot of things on Vesta that we didn't expect, so I'm expecting the unexpected at Ceres," she added.

The Dawn science team comprises 22 co-investigators and an additional 21 participating scientists (18 from the U.S.) who joined the mission for Vesta only. An announcement of opportunity is soon coming out for a new group of participating scientists for the Ceres portion of the mission. Also, Raymond added, about 45 associates

(U.S. and Europe) are actively working on the mission.

At Vesta, the team was prepared to deal with problems, said Rayman. "We had glitches, anomalies, a few safing events; it wasn't all perfect. The rapidity with which the team overcame every obstacle really impressed me. It is thanks to them that the exploration of Vesta was so extraordinarily productive."

Rayman noted that one of Dawn's four reaction wheels developed increased friction during Dawn's spiral departure from Vesta. Another wheel had experienced a similar condition in 2010. The operations team is now planning for Ceres using an attitude control mode with two reaction wheels plus the hydrazine reaction control system. Software for this capability was installed in the main flight computer in 2011 before Vesta operations began.

Mase praised the efforts of Dawn's small flight team, about 45 in all at JPL working on the Discovery Program mission. "We were under tremendous time pressure at Vesta to complete all of the ambitious science plans on a schedule that would allow us to maintain our arrival date at Ceres," he said. "I am very proud of this team, which quietly performed an amazing job, successfully executing the plan, one intense activity after another, for more than a year. As a team, we accomplished a truly staggering engineering feat, successfully achieving all that we set out to do, and bringing home more science data and discoveries than we imagined."

Raymond extolled another virtue of the benefits of ion propulsion.

"Personally it's wonderful to not have to go through the ordeal of getting a spacecraft ready to launch from Earth and do another mission," she said. "Here we are, just turning the engine on, spiraling up and cruising to our next destination. It's really nice."

"I hope that this mode of exploration can be used a lot more in the future."

Study sees asteroid lasso this decade

By Susan Braunheim

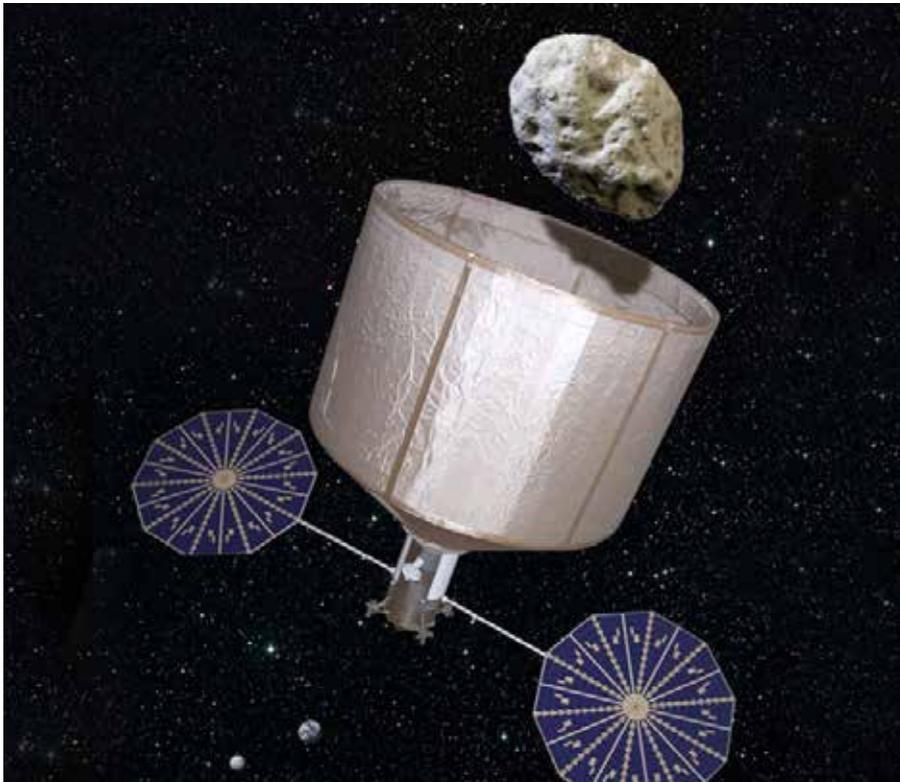


Image courtesy of Rick Sternbach / Keck Institute for Space Studies

Imagine this mission of the future: A robotic spacecraft travels to a near-Earth asteroid and uses a high-power ion propulsion system to tow it into orbit around Earth's moon. Crews travel out to the massive rock on a regular basis to study, analyze and dissect it in order to determine how to extract its valuable resources.

Sound crazy? Not to a group of scientists organized by campus' Keck Institute for Space Studies.

John Brophy, a JPL principal engineer specializing in electric propulsion technology, was a Keck Institute co-lead—along with Louis Friedman of

the Planetary Society and Fred Culick of Caltech—for the six-month study conducted between September 2011 and February 2012.

"The idea to exploit the resources of asteroids is not a new one," Brophy said. "But what is new is the emerging recognition that for the first time in history it could be done with technologies that could be made available in this decade."

An earlier NASA study, also led by Brophy, suggested that an asteroid capture and return project could be done. "Leon Alkalai recognized the value in this concept and encouraged me to continue

to pursue it even though it could easily appear to many to be a wacky concept. His encouragement was invaluable," said Brophy. Alkalai is JPL's deputy program manager for the Mission Formulation Office, Solar System Exploration Directorate.

In order to determine if the mission was possible, the study identified three key enabling conditions.

First, multiple near-Earth asteroids with the correct characteristics would have to be discovered and characterized. Attractive candidate asteroids needed to be rich in water, small enough (about 7 meters in diameter), and with the right orbital characteristics to transport. Asteroid 2008HU4, believed to be about the right size with the right orbital characteristics, was used in the study for proof-of-concept trajectory analysis.

Second, the study team determined that a sufficiently powerful solar electric propulsion system would be capable of rendezvousing with and transporting the near-Earth asteroid in a reasonable flight time from a single launch. A solar electric propulsion system similar to, but larger, than the one used on the Dawn spacecraft would be required.

The final key in the development is the planned capability for human exploration in cislunar space, the space between Earth and the moon. Humans would be needed to examine, sample, dissect and ultimately learn how to extract the desired materials from the retrieved asteroid in a microgravity environment. The Keck study team concluded that placing a 7-meter diameter, 500-metric-ton aster-

oid in high lunar orbit would in fact provide a unique, meaningful destination for astronaut crews in the next decade.

"The participants in the study were initially enthusiastic but highly skeptical that an asteroid capture and return mission could be feasible in the near future," Brophy said. "At the end of the study the participants were still enthusiastic and thanks to their own expertise in identifying and addressing issues they are now cautiously optimistic."

Such a mission could also have a significant bearing on planetary defense activities, such as moving an asteroid or other body headed toward Earth in the future, as well as other asteroid science.

The study also identified that an asteroid retrieval mission could represent the start of a new synergy between robotic and human missions. A 500-ton asteroid may eventually be able to produce 100 tons of water that could be used for radiation shielding, rocket fuel, oxygen or drinking water, all essential for farther space travel.

"It could be the key to jump-starting an entire industry based on the use of extraterrestrial resources to further human space exploration, an idea that everyone knows will eventually be needed but one that is exceptionally difficult to get started," Brophy said. "So far, the only extraterrestrial resources that we exploit on a regular basis are solar power, starlight for navigation, and an occasional gravity assist. But solar power harnessed through solar electric propulsion may be the key to unlocking vast material resources in space."

Infographics: From data into art

JPL Infographics, a new website and resource database, is asking the public to take on a visual challenge by transforming NASA data into scientific works of art to uncover new ways of explaining and understanding space exploration.

Information graphics, or infographics, are graphic visual representations of information, data or knowledge. These graphics present complex information quickly and clearly.

The site, <http://www.jpl.nasa.gov/infographics>, provides extensive collections of NASA science and mission data, graphics and space images that users can download to create their own infographics. These creative illustrations

can then be uploaded, reviewed by JPL experts and shared in a public gallery on the JPL website. Users can sign in on Facebook and begin sharing creations there also.

"An infographic is essentially artwork for your brain," noted Jon Nelson, manager of JPL's Online Publishing Group (1811). "It's a way of taking numbers, spreadsheets and all kinds of other technical data and turning it into a one-page, easily digestible fun-to-look-at graphic."

Infographics' combination of science data and design may also bring in a new audience and inspire those who have seen the data before to envision it in a new light.



New life for former reconnaissance satellites?

JPL is studying refurbishment of telescopes for science missions

By Mark Whalen

Two space-based telescopes originally designed for intelligence missions on behalf of the National Reconnaissance Office have recently been made available to NASA. One of these may find a new career chasing dark matter and hunting exoplanets for NASA's Science Mission Directorate under the guidance of JPL engineers and scientists.

The two telescopes—each 94 inches in diameter, the same size as the Hubble Space Telescope but using more advanced materials and optics—were declared excess to NRO needs and ultimately transferred to NASA. “These optical systems offer a much wider field-of-view design and, therefore, some capabilities that far exceed those of Hubble,” said Richard Capps of JPL's Exoplanet Exploration Program Office.

A preliminary NASA multi-center study led by JPL ensured the assets have substantial value to future science. This effort focused on the science identified in the most recent astrophysics decadal survey carried out by the National Academy of Sciences and provided a necessary “sanity check” about the performance and potential costs related to one design solution.

During the next six months, NASA will initiate two studies supported by JPL and NASA's Goddard Space Flight Center to look in more detail at potential uses for these two telescopes.

The first study will examine the feasibility of using one telescope for a mission combining investigations of exoplanets, dark energy and near-infrared surveys—in the process achieving the highest-priority recommendations of the decadal survey. This mission concept is called the Wide Field Infrared Survey Telescope, or

WFIRST in the astrophysics decadal. One focus of the new NASA science definition team will be inclusion of an option for a coronagraph as part of the science instrument suite; the feasibility of such an instrument would be studied by JPL specifically to detect and characterize exoplanets.

A second NASA study will work much more broadly across applications throughout the agency, including heliophysics, planetary science, or astrophysical missions not prioritized in the decadal. Applications in technology development and validation will also be in scope, as will the potential role of existing human spaceflight capabilities (e.g., the International Space Station) and future systems like the Space Launch System and the Orion Multi-Purpose Crew Vehicle. “Some have suggested potentially sending the second telescope to orbit Mars or to other planets to do mapping—it's really wide open,” noted Jennifer Dooley, supervisor of JPL's Payloads and Observing Systems Engineering Group.

The telescope equipment transferred to NASA includes the primary and secondary mirror and structure plus some supporting hardware and spare parts. The telescopes are currently in storage at ITT/Excelis, in Rochester, NY. The company built the hardware between the late 1990s and early 2000s.

Dooley is gathering the JPL engineers who will be working with the existing Goddard WFIRST study team. Goddard supported earlier studies of WFIRST design reference missions with JPL engineering support for smaller, cost-constrained telescope concepts. The new team will use this engineering base to

examine the larger telescope's capability to achieve the WFIRST scientific goals, she said.

The JPL/Goddard team will begin in earnest in October with the inspection of telescope hardware and supporting components. “We're going to be assessing what we have to start with as we import technical data from ITT/Excelis,” said Dooley. The completed study will provide a concept description followed by an independent cost review that NASA will integrate into its budget planning.

The telescopes were designed to look down at Earth rather than out into space. “We'll be looking at optical design revisions, accommodation of the concept instruments, and assessments of how the wavefront of the telescope and the beam quality change at different temperatures,” said Dooley. “We'll also provide a thermal design that's appropriate for the environment.” Instead of orbiting Earth, she said,

the telescopes will likely orbit a position such as the Lagrange 2 point, or take up a heliocentric or geocentric orbit to facilitate servicing. “That will feed directly into the instrument providers' assessments of what their instruments are going to be able to do, and the science team's assessments of the science they can accomplish,” she said.

“There has been a lot of interest in seeing something the nation has invested in being put to good use by returning exciting science, especially if we can get something launched before the middle of the next decade,” Dooley added.

“We'd love to see a concept that does great science, that's affordable, and could get started quickly—much sooner than what's on the current books,” she said. “We want to pull together a viable, attractive concept that would figure into NASA's future planning and priorities. And we'd love to be a part of that implementation.”

The first study will examine the feasibility of using one telescope for a mission combining investigations of exoplanets, dark energy, and near-infrared surveys.

A second NASA study will work much more broadly across applications throughout the agency.

The 2.4-meter space telescope form (right), for which about 5.8 cubic meters volume is available for instruments, sensors and electronics. Mass is 840 kilograms.



News Briefs



Bock



Brophy



Green



Redding

Four named JPL Fellows

Four JPL researchers have been named JPL fellows, the highest level on the Laboratory's individual contributor career ladder. Those chosen for 2012:

James Bock: For extraordinary leadership in the development of highly sensitive cryogenic detectors and arrays for long-wavelength astronomy and studies of the cosmic microwave background, thereby positioning Caltech-JPL at the forefront of ground-breaking scientific missions and exciting discoveries in cosmology and extragalactic astrophysics.

John Brophy: For outstanding leadership and overall systems engineering in the theoretical research, technological development and mission infusion of various electric propulsion solutions, thereby reaffirming JPL's leadership

position in the field of advanced propulsion engineering.

Robert Green: For outstanding leadership and seminal contributions to the field of imaging spectroscopy, pioneering the characterization of spectral performance and instrument application to address many Earth and planetary science problems, and for championing this field for current and future NASA missions.

David Redding: For exceptional leadership in the development and application of wavefront sensing and control systems, a critical technology for large optical systems integral to both NASA and non-NASA work.

JPL fellows are sought out for advice on strategic technical decisions and contribute to establishing the course for JPL's future.

Shuttle Endeavour flies over Lab

As part of its tour of California landmarks to end its flight career, Space Shuttle Endeavour roared overhead JPL atop a NASA 747 aircraft on Sept. 21 at about 12:10 p.m.

The four-hour, 34-minute flight began at NASA's Dryden Flight Research Center at Edwards Air Force Base, and over the ensuing hours the pair made low-level flybys over scores of California cities and landmarks, many of which had direct ties to NASA's space shuttle program over the past 40 years, including Vandenberg Air Force Base on the California coast, before entering the Los Angeles area.

The shuttle is now at Los Angeles International Airport preparing for a journey through city streets Oct. 12-13 to its new home at the California Science Center in Los Angeles for permanent display.



Photo by Kim Johansen-McCurdy

Passings



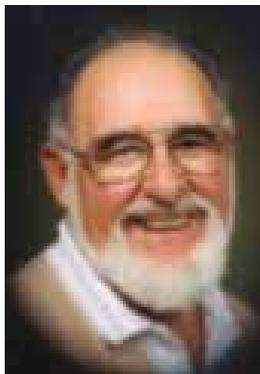
Irving Webb

Irving Webb, 75, a retired electrical engineer, died April 11.

Webb joined the Lab in 1971 and retired in 2001. He served as ground operations manager for the Ulysses mission, and also contributed to Viking, Voyagers 1 and 2, Magellan and Galileo.

Webb is survived by his wife, Gladys, son James, daughter Sabrina, seven grandchildren and a great-grandson. Burial took place April 18 in the veterans' section of Eternal Valley Memorial Park in Santa Clarita.

Distaso is survived by his wife, Pam (5X); brothers Stephen and Michael; twin sons Chris and Greg; and five grandchildren. Burial was in Riverside National Cemetery.



George Courville

George Courville, 86, a retired propulsion engineer, died Aug. 7.

Courville joined the Lab in 1956. He was a member of the Flight Systems Development Group in the Propulsion Systems Section, responsible for developing nozzles to provide thrust to guide spacecraft to their targets. Courville contributed to the Ranger, Mariner, Viking, Voyager and Galileo missions. He retired in 1986 as chief attitude control engineer.

Courville is survived by his wife, Darlene, son George Jr., daughter Lane and many grandchildren. Services were held Aug. 10 in Sun Lakes, Ariz.

Robert Mayne, retired supervisor of the Advanced Technology Electronic Packaging Group, died Aug. 7.

Mayne joined the Lab in 1963. Prior to becoming a group supervisor, he was an electronic packaging engineer in the Ranger Program, and later performed development work for Voyager 71 and future spacecraft. He retired in 1997.

Mayne is survived by his wife, Ange Maya Guangzhou.

Former JPLer **John W. Gustafson**, 81, died Aug. 16.

Gustafson worked in the Space Flight Operations Section. Funeral services were held at Central Filipino Adventist Church in Eagle Rock.

Jacob "Jake" Matijevic, 64, a principal engineer and key figure in Mars rover vehicle design, development and operation, died Aug. 20.

Matijevic, with JPL since 1981, was manager of microrover development for the Mars program in 1995-96. Recognized for both his technical expertise and leadership qualities, he contributed to the Mars Pathfinder, Mars Exploration Rovers and Mars Science Laboratory missions. His last assignment was as surface operations systems chief engineer for Mars Science Laboratory, which honored his memory by naming the first rock touched by the Curiosity rover's arm after him.

Among his honors, Matijevic earned the NASA Outstanding Leadership

Medal (1998), Aviation Week & Space Technology magazine Laureates Hall of Fame (1999), NASA Exceptional Achievement Medal (2006), and as a part of the Mars Exploration Rover Operations Team, the International Space Ops Award for Outstanding Achievement (2010).

A memorial mass was held Sept. 1 in Chicago. Memorial gifts may be made to the Mount Carmel High School Educational Foundation, 6410 S. Dante Ave., Chicago, IL 60637.



Jacob Matijevic



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Pete Distaso

Pete Distaso, 66, died June 23.

An electrician in the Space Flight Operations Facility facilities maintenance and operations, he supported projects in Buildings 230 and 264 from 1986 until 1994.

Letters

Thank you to my JPL friends and colleagues for your support and kind words during my husband's long illness and subsequent passing. Your support is helping me work through difficult times, and is much appreciated. Thanks also to JPL for the beautiful plant that was sent in Pete's memory.

Pam Distaso

On behalf of my mother, Sally Colella, and my family, please accept our sincerest thanks for the many words of comfort and condolences shared with us on the passing of my father, Frank. The outpouring of sympathy we have received has meant so much to us and

we will always hold, with great affection, the countless prayers, good wishes and memories that so many of you shared with us during this time of transition. My father had such high regard for the many friendships he made throughout his years at JPL and he took great pride in the work that his JPL family accomplished. It has given his family great solace knowing that the affection was reciprocated. Thank you.

Frances Colella

Retirees

The following employee retired in September: **Laverne Hall**, 20 years, Section 388.