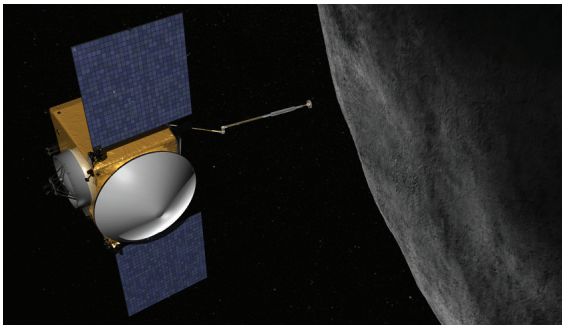
National Aeronautics and Space Administration


# OSIRIS-REx Gets Green Light

OSIRIS-REx reached a major milestone on May 15 when the asteroid sample return mission passed a confirmation review called Key Decision Point (KDP)-C. NASA officials reviewed a series of detailed project assessments and gave the team the authority to proceed with development and launch in 2016.

OSIRIS-REx, short for the Origins-Spectral Interpretation Resource Identification Security Regolith Explorer, will rendezvous with the asteroid Bennu in 2018 and return a sample of it to Earth in 2023.



*Artist's concept of the spacecraft at asteroid Bennu.*

Bennu could hold clues to the origin of the solar system. OSIRIS-REx will map the asteroid's global properties, measure non-gravitational forces and provide observations that can be compared with data obtained by telescope observations from Earth. OSIRIS-REx will collect a minimum of 2 ounces of surface material. Watch a video that describes how the samples will be grabbed and returned to Earth.

The design and development phase includes finalizing the design of the flight system, building and testing all of the flight system components, assembling and testing the spacecraft, and launching OSIRIS-REx towards its rendezvous with Bennu. The ground system to support the mission is developed in parallel with the flight system.

A key objective is to get the ground system, operations team, and the science team fully integrated and ready for the encounter with Bennu. "The entire OSIRIS-REx team has worked very hard to get to this point. We have a long way to go before we arrive at Bennu in 2018, but I have every confidence that when we do, we will have built a supremely capable system to return a sample of this primitive asteroid," said Dante Lauretta, OSIRIS-REx principal investigator from the University of Arizona, Tucson.

The mission successfully completed a series of system preliminary design reviews (PDRs) earlier this year, culminating in a mission PDR held at Lockheed Martin in Denver in March. The project successfully met the review criteria, leading to confirmation.

The project will be a vital part of NASA's plans to find, study, capture and relocate an asteroid for exploration by astronauts. NASA recently announced an asteroid initiative proposing a strategy to leverage human and robotic activities for the first human mission to an asteroid while also accelerating efforts to improve detection and characterization of asteroids.

### Education and Public Outreach Highlights

The asteroid's new name, Bennu, was announced on May 1. It was suggested by Mike Puzio, a third-grader from North Carolina. He submitted the winning entry from among more than 8,000 submitted in a contest sponsored by the OSIRIS-REx team at the University of Arizona, The Planetary Society and MIT Lincoln Laboratory (discoverers of the asteroid).

Mike suggested the name because he imagined the Touch-and-Go Sample Mechanism (TAGSAM) arm and solar panels on OSIRIS-REx look like the like neck and wings in drawings of Bennu, which Egyptians usually depicted as a gray heron. Bruce Betts, a Planetary Society judge in the competition, said, "The name 'Bennu' struck a chord with many of us right away. The similarity between the image of the heron and the TAGSAM arm of OSIRIS-REx was a clever choice. The parallel with asteroids as both bringers of life and as destructive forces in the solar system also created a great opportunity to teach about planetary science."

Target Asteroids!, an opportunity for amateur astronomers to participate in a long-term citizen science project that will contribute to basic scientific understanding of Near-Earth Objects (NEOs), has more than 150 registered users who have generated 44 sets of data and observed 15 NEOs to date. Register today.

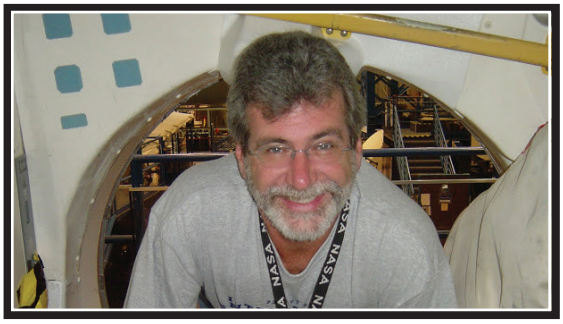
Watch principal investigator Dante Lauretta's recent TEDxTuscon Salon talk, "Will Asteroids End the World?"

INSIDE

May 2013 • Volume 14 Number 1

# Remembering Two Colleagues Gone Far Too Soon: Tom Hushka and Steve McClard

The Discovery and New Frontiers Program Office recently lost two treasured co-workers and friends, Tom Hushka who died on January 12 and Steve McClard who passed away on March 31. Both were 59 years old and passed away very suddenly, leaving family, friends and colleagues around the country shocked and saddened.



*Tom Hushka*

Tom Hushka was a U.S. Navy veteran who served in Vietnam. He became an aerospace engineer and worked at Ball Aerospace in Boulder, then spent several years in Germany as a contractor supporting European Space Agency missions. He returned to the U.S. in 1993 and began working as a contractor on the ground system for the Chandra X-ray Observatory at the Marshall Space Flight Center in Huntsville. After Chandra launched in 1999, he became a payload operations director for the International Space Station. Tom joined the program office in 2008, working program integration support. Tom leaves two children, son Andrew and daughter Becky.

Below are memories from some who worked closely with him:

*"There are very few people in my career that I could trust and depend on as I did Tom. Tom was hard-working and dependable and competent. If you needed something done, you could rely on him to do a good, careful job."*

*"Tom was hard-working, but he was also easygoing. …. He liked people; I don't know anyone who disliked him. He liked a good time; he liked a good beer. Think the quintessential German at a beer garden."*

*"Tom was friendly, personable, likeable. He and I were, in many ways, polar opposites. I am a liberal Californian, introverted, academic; he was a conservative Coloradan, extroverted, active. Yet, even I liked him."*

*"Tom was great to work with — he was supportive and smart and such a hard worker. I appreciate the support and the help he gave me, and I wish I had told him that more often. He is missed."*

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Steve McClard was born in Glen Ridge, New Jersey, and was a longtime resident of Huntsville, Alabama. He recently moved to Pulaski, Tennessee, to a dream home he designed and built only months prior to his passing. He is survived by his wife, Elizabeth; son, Brian; daughter, Whitney Stringer; granddaughter, Kaiya Stringer; and sister, Suzanne Ward.

Steve graduated from Auburn University with a degree in electrical engineering, and he remained an avid fan of Auburn football. After graduation, he worked briefly at Teledyne Brown Engineering, then obtained a position at NASA. He joined the program office shortly after it moved to Marshall in 2004, initially providing nuclear launch support to shepherd the New Horizons mission to Pluto through the launch approval process. He then moved into a mission manager role where, over the next seven years, he supported M3, Stardust, Kepler, LADEE, and OSIRIS-REx.

He was recognized with a Silver Snoopy Award, a special NASA honor for outstanding achievements related to human flight safety or mission success.

Steve's co-workers in the program office and those who worked on the many missions he supported will greatly miss his guidance and dedication. Here are some of their thoughts:

*"Steve really enjoyed what he did, and it showed in the way he explained his past and current projects to me. He was extremely helpful in growing my knowledge of the office, its responsibilities, and the missions our office supported. We were typically the early bird arrivals into the office, so we often walked to our offices together — typically talking about something related to Auburn. I miss those talks with my fellow Auburn alumni."*

*Steve McClard*

*"We spent most of our time together working Kepler. Steve had a significant role toward Kepler not being cancelled, and ultimately Kepler's success. Steve worked hard to ensure mission success…. he asked the hard questions, brought in the experts to ask even harder questions."*

*"Steve isn't someone you would think of as an outdoorsman, but he loved the outdoors, in particular the national parks. And he loved his wife very much. Every year, he and Beth would climb into their RV and head out to explore. We talked many times about his trips, and his plans for the next trip."*

*"Steve's spirit never flagged. He knew he had the Myelodysplastic Syndrome (MDS) hanging over his head, and sometimes he would talk about it. But never depressed, always as something to be faced.…When he found out his MDS had, after 15 years, progressed to leukemia, he endured chemotherapy and fought as hard as he could. Within about 6 weeks, he was gone."*

One final tribute:

*"When I needed help, whether it was information to complete a task, advice on a problem, or a clue how to get started, Tom and Steve were the first two people I went to see. Tom's quick wit and wonderful sense of humor made everyone laugh. Steve's kind, thoughtful attitude put people at ease and made everyone feel comfortable with him. It's odd that, even though they were both about my age, I feel like they mentored me here. But it's not surprising because they were both outstanding professionals."*

# GRAIL Concludes Data Collection; Focus Now on Analysis

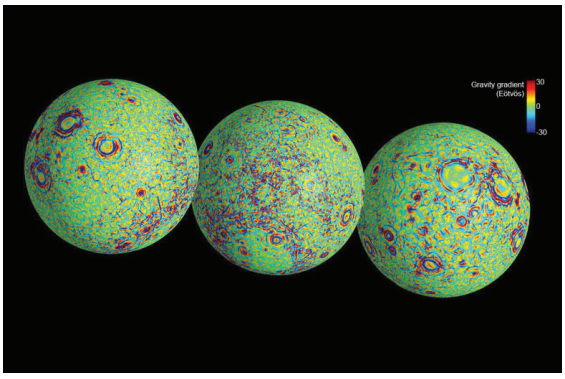
After a year in orbit around the Moon and six months of successful data collection, the Gravity Recovery and Interior Laboratory (GRAIL) mission ended with a bang on December 17, as the twin spacecraft, Ebb and Flow, were directed into a lower orbit that resulted in their impact near the lunar north pole. The formation-flying pair hit the surface at a speed of 3,760 mph. The mission is now in the Science Data Analysis Phase, which will continue through May 31, 2014.

On May 30, GRAIL scientists announced a major discovery – the mission uncovered the origin of massive invisible regions that make the Moon's gravity uneven, a phenomenon that affects the operations of lunar-orbiting spacecraft.

GRAIL's twin spacecraft studied the internal structure and composition of the Moon in unprecedented detail. They pinpointed the locations of large, dense regions called mass concentrations, or mascons, which are characterized by strong gravitational pull. Mascons lurk beneath the lunar surface and cannot be seen by normal optical cameras.

GRAIL data confirm that lunar mascons were generated when large asteroids or comets impacted the ancient Moon, when its interior was much hotter than it is now. Scientists believe the data from GRAIL show how the Moon's light crust and dense mantle combined with the shock of a large impact to create the mascons. The findings are published in the May 30 edition of the journal Science.

GRAIL accomplished its science goal of generating a high-resolution map of the Moon's gravity field, allowing scientists to learn about the lunar internal structure and composition in unprecedented detail. The gravity field map reveals an abundance of features never before seen in detail, such as tectonic structures, volcanic landforms, basin rings, crater central peaks and numerous simple, bowl-shaped craters. Data also show the Moon's gravity field is unlike that of any terrestrial planet in our solar system. Read details in three articles published in Science magazine in February.

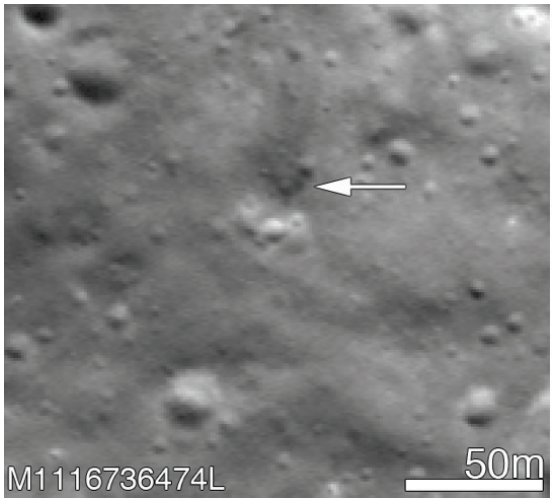



*These maps of the near and far side of the Moon show gravity gradients as measured by GRAIL. Red and blue areas indicate stronger gradients due to underlying mass anomalies. Credit: NASA/JPL-Caltech/CSM*

NASA named the impact area the Sally K. Ride Impact Site in honor of the late astronaut Sally K. Ride, who was America's first woman in space and a member of the mission team. The location is on the southern face of an approximately 1.5-mile-tall mountain near a crater named Goldschmidt.

Launched in September 2011, Ebb and Flow had been orbiting the Moon since January 1, 2012. The prime science data collecting phase of the mission was March – May 2012. NASA agreed to an extension of the science mission, which began on September 30, 2012, to get an even closer look at the Moon's gravity field. The probes were intentionally sent into the lunar surface because they did not have sufficient altitude or fuel to continue science operations.

NASA's Lunar Reconnaissance Orbiter, which is orbiting the Moon and making high-resolution maps of its surface, was about 100 miles from the lunar surface at the time of the GRAIL impact. It captured images and spectroscopic data after the crash. LRO scientists determined that both craters were relatively small, about 13 to 20 feet in diameter, and both had faint, dark, ejecta patterns, which is unusual as fresh impact craters on the Moon are typically bright. These may have been dark due to spacecraft material being mixed with the ejecta.




*LRO image shows the impact site of the Flow spacecraft. Credit: NASA/GSFC/Arizona State University.*

LRO complemented the GRAIL mission in other ways as well. Combining LRO's topography map with GRAIL's gravity map yielded some very interesting results. Scientists expected that areas with mountains have a little stronger gravity, while features like craters have a little less. However, when they subtracted out the topography, the map reveals gravity differences that are not tied to the surface, providing insight into structures deeper in the Moon's interior.

### Education and Public Outreach

GRAIL was NASA's first planetary mission to carry cameras fully dedicated to education and public outreach. GRAIL's MoonKAM (Moon Knowledge Acquired by Middle School Students) Program, led by Sally Ride Science in San Diego, consisted of one MoonKAM camera on each of the spacecraft that took more than 115,000 images of the lunar surface. Imaging targets were proposed by middle school students from across the country, and the resulting images were returned for them to study. The images will remain available on the website for viewing and studying by classrooms worldwide.

# MESSENGER's Discoveries Among Top Space Stories of 2012

**MESSENGER Finds:**

- **New Evidence for Water Ice at Mercury's Poles**
- **Chemical Diversity on Mercury's Surface**
- **Unusual Groups of Ridges and Troughs**
- **Measures Waves at the Boundary of Mercury's Magnetosphere**
- **Provides New Look at Mercury's Landscape, Metallic Core and Polar Shadows**

These headlines showcased new discoveries from the MESSENGER mission to Mercury in 2012. The spacecraft's accomplishments captured the attention of many media outlets, and several designated MESSENGER's findings as a "top story" of the year.

Observations by MESSENGER provided compelling support for the long-held hypothesis that Mercury harbors abundant water ice and other frozen volatile materials in its permanently shadowed polar craters. Three independent lines of evidence support this conclusion. The findings are presented in three papers published in Science in November.

Given its proximity to the Sun, Mercury would seem to be an unlikely place to find ice. But the tilt of Mercury's rotational axis is less than one degree, so there are pockets at the planet's poles that never see sunlight. Scientists suggested decades ago that there might be water ice and other frozen volatiles trapped at Mercury's poles. Now the data from MESSENGER strongly indicate that water ice is the major constituent of Mercury's north polar deposits.

Another important finding is the chemical diversity on Mercury's surface. Data from the X-Ray Spectrometer show variations in the composition of surface material on Mercury that indicate changes over time in the characteristics of volcanic eruptions.

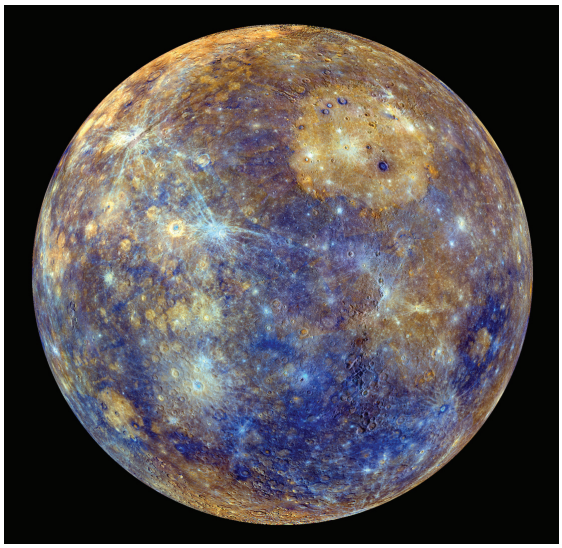
In results published in the Journal of Geophysical Research, scientists report that Mercury's volcanic smooth plains differ in composition from older surrounding terrain, suggesting that the smooth plains material erupted from a magma source that was chemically different from the source of the material in the older regions.

Lead author Shoshana Weider of the Carnegie Institution of Washington and her co-authors also reported that Mercury's surface is dominated by minerals high in magnesium and enriched in sulfur. "None of the other terrestrial planets have such high levels of sulfur. We are seeing about ten times the amount of sulfur than on Earth and Mars." As the team starts to work out what kinds of minerals are present and the types of rocks that were formed, they can start to unravel Mercury's geological history.

Read more about these discoveries and others in the mission's 2012 news archive.

In March the team announced that the Mercury Dual Imaging System had finally imaged 100% of the planet. The global images have produced many important discoveries about how Mercury's crust formed and evolved, but all of the findings have raised new questions. As the spacecraft began its 2,000th orbit around Mercury on May 22, the team awaits word from NASA on a proposal for a second extended mission, with hopes of continuing targeted observations, making more new discoveries, and furthering our understanding of the closest planet to the Sun.

Watch a video of this colorful view of Mercury as a spinning globe.



*This view of Mercury uses colors to enhance the chemical, mineralogical and physical differences between the rocks on the surface. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/ Carnegie Institution of Washington*

### Education and Public Outreach Highlights

MESSENGER has partnered with CosmoQuest on 'Mercury Mappers', a new citizen science project. The beta version allows Mercury enthusiasts to be among the first to access high-resolution images of Mercury and assist mission scientists in identifying craters, boulders and other features.

Listen to a podcast from *365 Days of Astronomy* based on the findings of water ice, called "Ice and Organic Goo on Mercury." All of the previous MESSENGER-related podcasts from the series are available on the MESSENGER website.

MESSENGER and the District of Columbia Space Grant Consortium once again sponsored the Family Science Night program at the Smithsonian's National Air and Space Museum on the National Mall. Five special evening events for more than 1,600 students, parents and teachers from 13 area schools took place in February and March.

Eleven MESSENGER Educator Fellows attended a training in conjunction with a science team meeting in February. They attended talks about science results and engineering challenges throughout the mission. The Fellows used the opportunity to conduct a public outreach event at the Maryland Science Center where they engaged approximately 200 visitors in mission-related educational activities.

MESSENGER participated in the Applied Physics Laboratory's "Girl Power" event in March which was attended by 800–1200 young girls and their families. MESSENGER also brought engaging ice activities to the NASA booth at the San Diego Festival of Science and Engineering in March. The festival attracted 25,000 visitors.

# Dawn Unravels Vesta's Past

Dawn scientists continue to review findings from the spacecraft's year in orbit around giant asteroid Vesta, including preliminary results of the geophysical and topographic mapping, while they prepare science gathering plans at Ceres. The ion propulsion system onboard the spacecraft keeps on thrusting its way to the icy dwarf planet for a planned rendezvous in early 2015.

The project team completed the development of a high-level plan for the Ceres mission. They have discussed lessons learned from Vesta operations and identified opportunities to improve processes and reliability for Ceres. The next phase of Ceres planning involves increasingly detailed mission analyses, simulations and robustness studies. An Operational Readiness Test was conducted in May to train new team members who have recently joined the project and refresh the processes and procedures for the team.

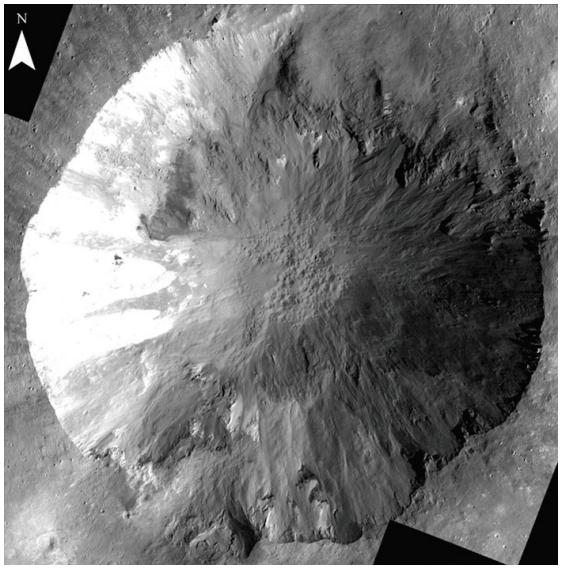
Dawn's discoveries at Vesta created lots of headlines in 2012 as scientists continue to publish their findings. Observations from two of Dawn's instruments suggest that hydrated materials were delivered to Vesta through a buildup of small particulates during an epoch when the solar system was rich in dust. This is a radically different process from the way hydrated materials have been deposited on the Moon and may have implications for the formation of terrestrial planets, including the delivery of the water that formed Earth's ocean. The Dawn team presented the findings at the European Planetary Science Congress in Madrid, Spain, in September. Learn more.

Enormous troughs that wrap around the giant asteroid Vesta may be dropped blocks of terrain bounded by fault lines, suggesting a geologic complexity beyond that of most asteroids. Since the discovery of the troughs last year, scientists have been working to determine the story behind these unusual features. The research reinforces the claim that Vesta has a core, mantle and crust, a structure normally reserved for larger bodies, such as planets and large moons. Read the full article in Geophysical Research Letters.

Early pictures of Vesta showed a variety of dramatic light and dark splotches on its surface. These light and dark materials were unexpected and now show the brightness range of Vesta is among the largest observed on rocky bodies in our solar system. Data from Dawn show that a form of weathering that occurs on the Moon and other airless bodies in the inner solar system does not alter Vesta's outermost layer in the same way. Findings indicate that Vesta "dirt" is very clean, well mixed and highly mobile. The results are described in two papers found in the journal Nature.

What is creating intriguing gullies that sculpt the walls of geologically young craters on Vesta? Scientists have found images that show narrow channels of two types — some look like straight chutes and others carve more sinuous trails and end in lobe-shaped deposits. The sinuous gullies are longer, narrower, and curvier than the short, wide, straight gullies. Scientists think different processes formed the two types of gullies and have been looking at images of Earth, Mars and other small bodies for clues. They are an exciting, unexpected finding that scientists are still trying to understand.

Images from Dawn that show remarkable, dark-as-coal material that speckles the surface of Vesta may help scientists better understand the impact environment early in the giant asteroid's evolution. Dawn scientists found that this carbon-rich material tends to appear around the edges of two giant impact basins in Vesta's southern hemisphere. The analysis suggests that the dark material was most likely delivered by the object that created the older of the two basins, known as Veneneia, about 2 to 3 billion years ago. Some of those materials were later covered up by the impact that created the younger basin, Rheasilvia. Read more here or find the complete paper in Icarus.




*This image shows examples of long, narrow, sinuous gullies that Dawn scientists discovered on the giant asteroid Vesta. The crater shown here is called Cornelia.*
*Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA*

### Education and Public Outreach Highlights

Dawn's new citizen science project, Asteroid Mappers, was launched in collaboration with CosmoQuest, using a data-gathering technique called crowd-sourcing in which end-users are invited to map features captured in images of asteroid Vesta taken by Dawn's framing camera.

Dawn and CosmoQuest hosted a Google+ HangOut in December to train citizen scientists on using Asteroid Mappers. Watch the video and join the fun. You too can be among the first to access fantastic high-resolution images while helping scientists identify craters, boulders and more.

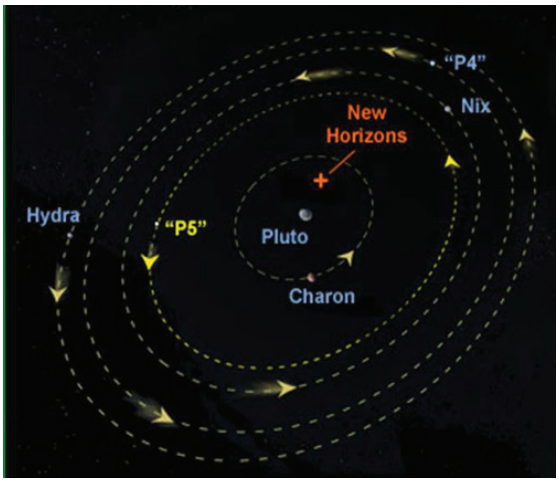
On May 8, a second Google+ Hangout, Unlocking Vesta's Mysteries, featured two of Dawn's participating scientists: Brett Denevi studies Vesta's regolith, the relatively fluffy surface layer, made of dust and rocky debris leftover by impacts. Paul Schenk explores Vesta's craters, especially their weird shapes — often caused by that shifting regolith — and the tales they tell of Vesta's history.

# New Horizons Plans For Hazards in Pluto System

The New Horizons spacecraft is now more than seven years into its 9½-year journey across the solar system to explore Pluto and its system of moons. In January 2015, New Horizons will begin encounter operations, which will culminate in a close approach to Pluto on July 14, 2015, and the first-ever exploration of a planet in the Kuiper Belt.

As New Horizons travels through space, its science team has become increasingly aware of the possibility that dangerous debris and even rings may be orbiting in the Pluto system, potentially putting the spacecraft and its objectives at risk.

"We've found more and more moons orbiting near Pluto — the count is now up to five," said principal investigator Alan Stern, "and we've come to appreciate that those moons, as well as any not yet discovered, act as debris generators, populating the Pluto system with shards from collisions between those moons and small Kuiper Belt objects."




*The discovery of more small moons raises concerns about even tiny objects in the Pluto system that can be hazardous to New Horizons. Credit: NASA/ESA/A. Feild (STScI)/Sky & Telescope*

Because the spacecraft is traveling so fast — more than 30,000 miles per hour — a collision with even a pea-sized object could cripple or destroy it. So the priority is to steer clear of any debris zones around Pluto.

The New Horizons team is using every available tool — from sophisticated computer simulations of the stability of debris orbiting Pluto, to giant ground-based telescopes, to stellar occultation probes of the Pluto system, to the Hubble Space Telescope — to search for debris in orbit. New studies show that the Pluto system appears to be safer than originally thought; even so, contingency plans are being prepared.

The team is plotting alternative, more distant courses through the Pluto system that would preserve most of the science mission but avert deadly collisions if the current flyby plan is found to be too hazardous. The project created a contingency "Safe Haven By Other Trajectory," or SHBOT, if the baseline trajectory is deemed unsafe. An Independent Review Board assessed the SHBOT architecture and concurred with the mission's findings. NASA management has given the project authority to proceed with the development of the Generic Inner SHBOT (GIS) and the Deep Inner SHBOT (DIS) contingency loads.

With all the planning taking place on Earth, the spacecraft keeps zooming closer to Pluto. It's now 25.56 AU from Earth (1 AU is 93 million miles). On May 21, the team woke the spacecraft from its most recent hibernation to begin a busy annual checkout, which will include thorough checks of all backup systems, instrument payload calibrations, and an update of the fault protection software. This summer's wakeup will also include the most comprehensive on-the-spacecraft close-encounter rehearsal. For nine days beginning July 5, New Horizons will execute all the activities of its final week on approach to Pluto, closest approach day, and then some of the post-encounter timeline as well. New Horizons will go back into hibernation on August 21 for another 4½ months, while the team works on SHBOT encounter sequencing.

The New Horizons project will be hosting a major scientific conference in July for the planetary science community from around the world to gather and review everything currently known about the Pluto system. The group will plan ground-based and space-based Pluto system observations to take place in concert with the New Horizons encounter and make scientific predictions about what we will learn from New Horizons. They will also learn about the spacecraft and payload's capabilities in preparation for analyzing data from the flyby.

### Education and Public Outreach Highlights

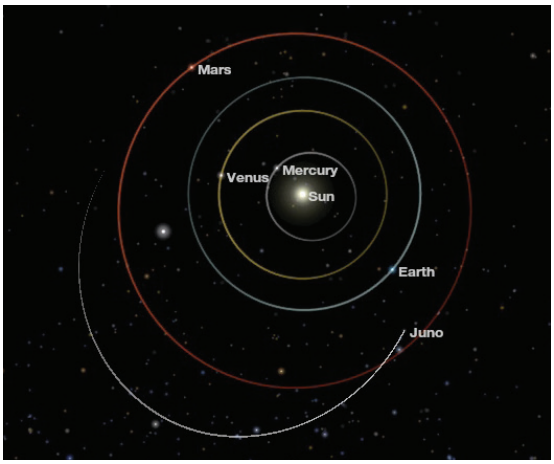
A workshop for educators on "Pluto and the Outer Solar System" drew 54 participants from across Maryland and surrounding states to the Maryland Science Center on March 9. The teachers learned a variety of activities to bring engaging solar system science to their students, focusing on the icy outer regions of Pluto and the Kuiper Belt. Activities included Science on a Sphere, Where Are We in the Solar System? How Big? How Far?, Investigating Icy Worlds, and Earth Calling. Participants also heard a comprehensive overview of the New Horizons mission from Dr. Ralph McNutt of The Johns Hopkins University Applied Physics Laboratory.

*Educators investigate a "strange new planet" during a workshop on March 9.*

## Juno Aims for October Earth Flyby

The Juno spacecraft is heading toward Earth as the mission operations team prepares for a gravity-assist flyby on October 9, to boost its speed on the long journey to Jupiter. The spacecraft has covered approximately 40% of the total distance it will travel on its five-year, looping path to the giant planet, on a mission to improve our understanding of the solar system's beginning by revealing the origin and evolution of Jupiter.

Once Juno enters into orbit, infrared and microwave instruments will measure the thermal radiation emanating from deep within Jupiter's atmosphere to determine the abundance of water. Other instruments will measure composition, temperature, cloud motions and more. Juno will map Jupiter's magnetic and gravity fields and study the magnetosphere near the poles, especially the auroras, to shed new light on how the enormous magnetic force field affects the atmosphere.




*Juno is making its way to Earth for a speed-boosting gravity assist in October.*

Available power to Juno's solar arrays continues to increase as the spacecraft heads closer to the Sun for the Earth flyby gravity-assist maneuver. On April 10, as planned, mission controllers reduced the amount of power flowing into the spacecraft from its solar arrays from 2200 watts to 500 watts. Once it arrives at Jupiter, Juno will operate on about 450 watts.

The mission's operations team performed a flush of the spacecraft's main engine on May 1, firing the engine for a few seconds. The team does this maintenance activity about once per year to flush contaminants out of the propellant lines that feed the main engine.

Juno is the second project selected in the New Frontiers Program. It launched in September 2011 and will arrive at Jupiter in 2016. Juno uses a spinning solar-powered spacecraft in a highly elliptical polar orbit that avoids most of Jupiter's high radiation regions.

Check out Juno's current position and learn even more on the Juno module at Eyes on the Solar System.

### Education and Public Outreach Highlights

Juno team members are reaching audiences nationwide — students, teachers and the public — to tell them about the mission on its way to Jupiter.

The flight spares of Juno's three LEGO mini figures and a LEGO model of the Juno spacecraft were displayed at the Smithsonian National Air and Space Museum's Space Day May 4, with 30,000-40,000 visitors in attendance.

JunoCam is Juno's visible-light camera specifically designed to engage the public by providing dramatic, close-up color views of Jupiter. The public will be involved in processing the images from raw data and even helping the science team determine which areas of Jupiter should be imaged by the spacecraft.

Follow the mission's progress at missionjuno.swri.edu, www.nasa.gov/juno, and on Facebook (NASAJuno) and Twitter (@NASAJuno).

## Works Heats Up on InSight Lander

InSight, the newest Discovery Program mission, will investigate the interior of Mars to help answer one of science's most fundamental questions: how did the terrestrial planets form? Short for *Interior Exploration using Seismic Investigations, Geodesy and Heat Transport*, InSight will delve below the surface to find clues about why Mars evolved so differently than Earth.

Planned for launch in 2016, InSight will place a single geophysical lander on the Red Planet to investigate whether the core of Mars is solid or liquid like Earth's and why Mars' crust is not divided into tectonic plates that drift like those on Earth. Detailed knowledge of the interior of Mars in comparison to Earth will help scientists understand how terrestrial planets form and evolve.

The lander will measure heat flow with an instrument that is designed to probe five meters below ground. With a firm strike every three seconds, the long cylinder model with a cone tip, called a mole, gives off the sound of an ax hitting a hard surface.

Each strike will get the instrument less than a millimeter down into the surface of the planet, so it will take thousands of tiny strikes to reach its goal. Once the instrument has been deployed to a depth of five meters, it will send back data for at least one Martian year to the lander through an attached heat-sensor-packed tether.

Along with the mole, the lander will be armed with a seismometer and radio tracking device, all designed to answer questions about how Mars formed, the amount of heat that radiates from its core and its crustal thickness. The spacecraft will land in an area on Mars blanketed with several large volcanoes, called Elysium Planitia.

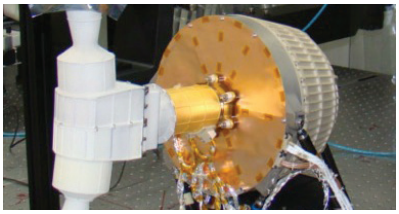
Since its selection last August, the InSight team presented at its first Project Status Review in early January. Since then monthly and quarterly management reviews have begun, along with contract negotiations, planning for compliance with planetary protection requirements, preliminary design reviews, instrument and software requirements reviews, subsystem heritage reviews and the project mission system review.

*Thanks to Tiffany Kelly of the La Cañada Valley Sun for the information on the "mole."*

## Strofio Testing, Integration, and Final Assembly Nears Completion

Strofio is a unique mass spectrometer that is part of the SERENA (Search for Exospheric Refilling and Emitted Natural Abundances) suite of instruments that will fly onboard the European Space Agency's BepiColombo/Mercury Planetary Orbiter (MPO) spacecraft. Strofio will determine the chemical composition of Mercury's surface, providing a powerful tool to study the planet's geological history. Strofio is a NASA-funded Discovery Mission of Opportunity.

The Proto-Flight Model (PFM) was shipped to the University of Bern (UB) in Switzerland last August. It was installed in the calibration chamber and reconfigured to the flight configuration. Calibration testing was completed late in December and results indicated that the flight instrument met or exceeded the performance requirements.



*Strofio flight configuration.*

In January a first-light test and additional ultraviolet and rest gas testing were successfully conducted on the Strofio PFM in the Mefisto chamber at UB. At the conclusion of this testing, the instrument was removed from the Mefisto chamber to begin final assembly operations. In February the flight instrument assembly and staking operations were completed. An acceptance level vibration test was conducted on the PFM in late February. During post-vibration performance testing of the flight instrument, a shorting of the cathodes was experienced as a result of a cathode installation design error.

In March an updated cathode installation design was qualified through sub-system testing. New flight cathodes were installed on the PFM and passed another acceptance level vibration test in April. The Strofio PFM was then placed in a storage chamber under vacuum. The final flight cathode will be installed on the PFM this summer, around the time that the Strofio Engineering Model velocity filter testing is conducted. The Strofio PFM will then be placed back in the storage chamber and held under vacuum at UB until needed for delivery to SERENA, planned for this fall.

Launch of BepiColombo is currently scheduled for August 2015, with arrival at Mercury in 2022.

## "Challenge of Discovery" Features Science–Engineering Collaboration

Nearly 150 teachers and informal educators came together at four sites nationwide on April 6 to participate in the third annual educator workshop sponsored by the Discovery and New Frontiers Programs.

In partnership with the MESSENGER, New Horizons, OSIRIS-REx, and Dawn missions, the "Challenge of Discovery" workshop featured teams of speakers from missions in different phases, from development to long cruise to mission operations to sample return. The emphasis was on the collaboration among team members from different areas of the mission that is essential to overcome challenges and ensure mission success.

Everyone watched the speakers at the other locations on a large screen and all had opportunities to ask questions. A live webinar broadcast drew nearly 100 viewers. Watch the speakers on the webinar archive page which also includes the activities demonstrated.

Keiko Nakamura-Messenger talked her role in analyzing grains of comet dust brought back to Earth in 2006 from the Stardust mission and her current responsibilities in deciding the best location for the OSIRIS-REx mission to grab a sample of dirt from asteroid Bennu.

MESSENGER speakers Nancy Chabot and Alice Berman reviewed the history of Mercury exploration and highlighted new findings of water ice at the poles. They also demonstrated a new activity called "Water Ice Data Exploration."

The four workshop sites were the Jet Propulsion Laboratory in Pasadena, CA; University of Arizona, Tucson; Johnson Space Center, Houston, TX; and the Applied Physics Laboratory, Laurel, MD.

*Special thanks to Whitney Cobb, Judy Counley, and Mary Cullen at McREL and to the site leaders: Julie Edmonds, Heather Weir, Kerri Beisser, Jaclyn Allen, Anna Spitz, and Ross Dubois.*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