

National Aeronautics and Space Administration



# GoddardView

Volume 9 Issue 13  
September 2013

**LADEE Update**

**NASA Spacecraft Embarks On Historic  
Journey Into Interstellar Space**

**The Genesis of Goddard**

## THE WEEKLY



**Goddard License Plates**  
NASA employees who live in Maryland can now show their pride through Goddard license plates. The specialty plate contains the NASA insignia and the initials of the father of rocketry, Dr. Robert Goddard. Click the picture for more information.

**Latest Life at Goddard**  
Click on the image to read the latest Life at Goddard. The latest features engineering as a competitive sport and a stunning photo feature. Life at Goddard is updated every week. Check Dateline for more information.



**Walk Around the Moon**  
"Walk Around the Moon" is coming the week of November 4. The center with the most cumulative miles will receive a trophy! Goddard needs a team name for this fitness challenge. The winning entry will receive a free two-week membership to the Goddard Greenbelt Fitness Center. [Email](#) your entry by Sep. 20.

**Engage: MAVEN**  
Join MAVEN Principal Investigator, Bruce Jakosky, for the next Engage on the Mars Atmosphere and Volatile Evolution mission on, September 25, 11:30-12:30 in Bldg. 3's Goett auditorium. Learn how this mission hopes to answer Mars climate questions. Click on the photo to learn more now.



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**On the cover:** A still camera on a sound trigger captured this photo of an airborne frog as LADEE lifts off from Pad 0B at Wallops Flight Facility. The photo team confirms the frog is real and was captured in a single frame by one of the remote cameras used to photograph the launch. The condition of the frog remains uncertain. Photo credit: NASA /Wallops Flight Facility/Chris Perry

## GoddardView

*Goddard View* is an official publication of NASA's Goddard Space Flight Center. *Goddard View* showcases people and achievements in the Goddard community that support Goddard's mission to explore, discover, and understand our dynamic universe. [Goddard View](#) is published weekly by the Office of Communications.

News items for publication in *Goddard View* must be received by noon Wednesday of each week. You may submit contributions to the editor via e-mail at [john.m.putman@nasa.gov](mailto:john.m.putman@nasa.gov). Ideas for new stories are welcome but will be published as space allows. All submissions are subject to editing.

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# LADEE UPDATE: INITIAL CHECKOUT COMPLETE

By: Rachel Hoover

**A**fter a spectacular launch, the Lunar Atmosphere and Dust Environment Explorer spacecraft was placed by the Minotaur V launch vehicle into an elliptic orbit around Earth, as the start of our journey to the moon. After adjusting some fault protection settings to enable the reaction wheels, mission controllers at NASA's [Ames Research Center](#) in Moffett Field, Calif., successfully completed the initial systems checkout phase, and everything looks good so far. This checkout included spacecraft acquisition, tracking, and ranging by all the ground stations. The propulsion system also was activated to do a momentum dump, which means that the spacecraft spin and the reaction wheel spins were reduced together to a nominal state.

LADEE is doing fine and its trajectory to the moon is good. The LADEE spacecraft is currently in an elliptical orbit around Earth, about 162,000 miles in altitude. Mission controllers are now performing an extended checkout phase including guidance, navigation and control characterization, reaction control system tests, and on-board controller tuning.

The spacecraft was at the highest point in the current orbit (apogee) at 9:30 a.m. PDT, Tuesday Sept. 10. Then it will drop back down to a closest approach to Earth (perigee) at 9:38 a.m. PDT on Friday, Sept. 13, where we will perform an engine burn to boost its orbit.

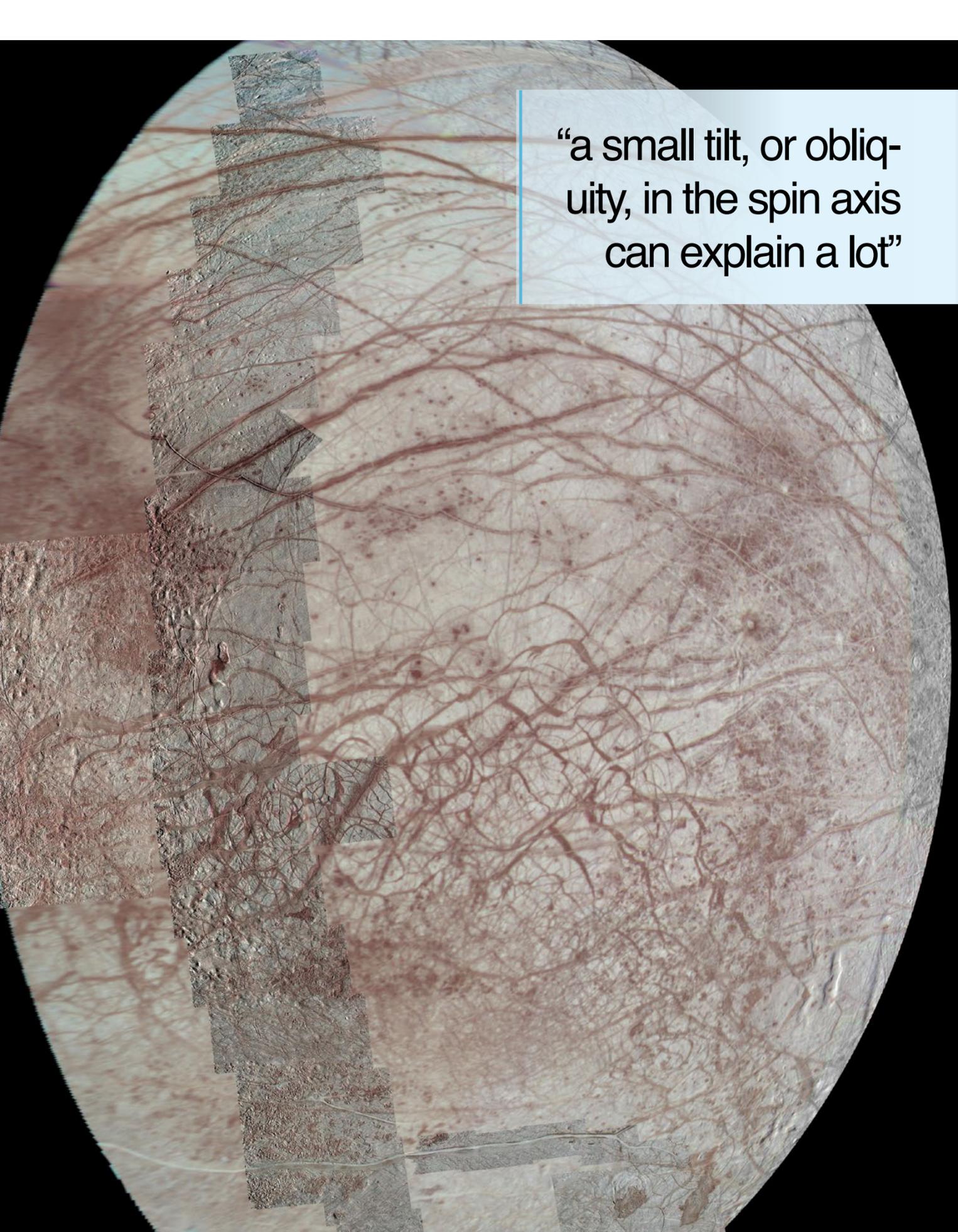
LADEE will continue with two more of these elliptical orbits until it is captured around the moon to do its initial Lunar Orbit Insertion burn on Sunday Oct. 6. After that we are in lunar orbit. This LOI burn is one of the most critical phases of the mission, because without it working we do not get into lunar orbit.

NASA's Lunar Atmosphere and Dust Environment Explorer is a robotic mission on its way to orbit the moon to gather detailed information about the lunar atmosphere, conditions near the surface and environmental influences on lunar dust. A thorough understanding of these characteristics will address long-standing unknowns, and help scientists understand other planetary bodies as well.

The spacecraft was successfully launched at 11:27 p.m. EDT Friday, Sept. 6, from Pad 0B at the Mid-Atlantic Regional Spaceport, at NASA's Wallops Flight Facility, Wallops Island, Va.

For more updates, click on the above image. ■

Above: The Lunar Atmosphere and Dust Environment Explorer spacecraft now is in an elliptic orbit around Earth, as the start of its journey to the moon. Image credit: NASA



“a small tilt, or obliquity, in the spin axis can explain a lot”

# LONG-STRESSED EUROPA LIKELY OFF-KILTER AT ONE TIME

By: Elizabeth Zubritsky, Nancy Neal-Jones and Jia-Rui C. Cook

**B**y analyzing the distinctive cracks lining the icy face of Europa, NASA scientists found evidence that this moon of Jupiter likely spun around a tilted axis at some point.

This tilt could influence calculations of how much of Europa’s history is recorded in its frozen shell, how much heat is generated by tides in its ocean, and even how long the ocean has been liquid.

“One of the mysteries of Europa is why the orientations of the long, straight cracks called lineaments have changed over time. It turns out that a small tilt, or obliquity, in the spin axis, sometime in the past, can explain a lot of what we see,” said Alyssa Rhoden, a postdoctoral fellow with [Oak Ridge Associated Universities](#) who is working at NASA’s Goddard Space Flight Center in Greenbelt, Md. She is the lead author of a paper in the September–October issue of *Icarus* that describes the results.

Europa’s network of crisscrossing cracks serves as a record of the stresses caused by massive tides in the moon’s global ocean. These tides occur because Europa travels around Jupiter in a slightly oval-shaped orbit. When Europa comes closer to the planet, the moon gets stretched like a rubber band, with the ocean height at the long ends rising nearly 100 feet. That’s roughly as high as the 2004 tsunami in the Indian Ocean, but it happens on a body that measures only about one-quarter of Earth’s diameter. When Europa moves farther from Jupiter, it relaxes back into the shape of a ball.

The moon’s ice layer has to stretch and flex to accommodate these changes, but when the stresses become too great, it cracks. The puzzling part is why the cracks point in different directions over time, even though the same side of Europa always faces Jupiter.

A leading explanation has been that Europa’s frozen outer shell might rotate slightly faster than the moon orbits Jupiter. If this out-of-sync rotation does occur, the same part of the ice shell would not always face Jupiter.

Rhoden and her Goddard co-author Terry Hurford put that idea to the test using images taken by NASA’s [Galileo](#) spacecraft during its nearly eight-year mission, which began in 1995. “Galileo produced many paradigm shifts in our understanding of Europa, one of which was the phenomena of out of sync rotation,” said Claudia Alexander of NASA’s Jet Propulsion Laboratory in Pasadena, Calif., who was the project manager when the Galileo mission ended.

Rhoden and Hurford compared the pattern of cracks in a key area near Europa’s equator to predictions based on three different explanations. The first set of predictions was based on the rotation of the ice shell. The second set assumed that Europa was spinning around a tilted axis, which, in turn, made the

orientation of the pole change over time. This effect, called precession, looks very much like what happens when a spinning toy top has started to slow down and wobble. The third explanation was that the cracks were laid out in random directions.

The researchers got the best performance when they assumed that precession had occurred, caused by a tilt of about one degree, and combined this effect with some random cracks, said Rhoden. Out-of-sync rotation was surprisingly unsuccessful, in part because Rhoden found an oversight in the original calculations for this model.

The results are compelling enough to satisfy Richard Greenberg, the University of Arizona professor who had earlier proposed the idea of out-of-sync rotation.

“By extracting new information from the Galileo data, this work refines and improves our understanding of the very unusual geology of Europa,” said Greenberg, who was Rhoden’s undergraduate advisor and Hurford’s graduate advisor.

The existence of tilt would not rule out the out-of-sync rotation, according to both Rhoden and Greenberg. But it does suggest that Europa’s cracks may be much more recent than previously thought. That’s because the spin pole direction may change by as much as a few degrees per day, completing one precession period over several months. On the other hand, with the leading explanation, one full rotation of the ice sheet would take roughly 250,000 years. In either case, several rotations would be needed to explain the crack patterns.

A tilt also could affect the estimates of the age of Europa’s ocean. Because tidal forces are thought to generate the heat that keeps Europa’s ocean liquid, a tilt in the spin axis might suggest that more heat is generated by tidal forces. This, in turn, might keep the ocean liquid longer.

The analysis does not specify when the tilt would have occurred. So far, measurements have not been made of the tilt of Europa’s axis, and this is one goal scientists have for Europa missions in the future.

“One of the fascinating open questions is how active Europa still is. If researchers pin down Europa’s current spin axis, then our findings would allow us to assess whether the clues we are finding on the moon’s surface are consistent with the present-day conditions,” said Rhoden. ■

Opposite: The distinctive cracks crisscrossing Europa’s icy surface are clues to the stresses that this moon of Jupiter has experienced. This mosaic image was taken by NASA’s Galileo satellite, which flew past this moon of Jupiter six times between 1996 and 1999. Image credit: NASA/JPL-Caltech/University of Arizona



# NASA SPACECRAFT EMBARKS ON HISTORIC JOURNEY INTO INTERSTELLAR SPACE

By: Jia-Rui C. Cook, D.C. Agle and Dwayne Brown

**N**ASA's Voyager 1 spacecraft officially is the first human-made object to venture into interstellar space. The 36-year-old probe is about 12 billion miles from our sun.

New and unexpected data indicate [Voyager 1](#) has been traveling for about one year through plasma, or ionized gas, present in the space between stars. Voyager is in a transitional region immediately outside the solar bubble, where some effects from our sun are still evident. A report on the analysis of this new data, an effort led by Don Gurnett and the plasma wave science team at the University of Iowa, Iowa City, is published in the journal *Science*.

"Now that we have new, key data, we believe this is mankind's historic leap into interstellar space," said Ed Stone, Voyager project scientist based at the California Institute of Technology, Pasadena. "The Voyager team needed time to analyze those observations and make sense of them. But we can now answer the question we've all been asking: 'Are we there yet?' Yes, we are."

Voyager 1 first detected the increased pressure of interstellar space on the heliosphere, the bubble of charged particles surrounding the sun that reaches far beyond the outer planets, in 2004. Scientists then ramped up their search for evidence of the spacecraft's interstellar arrival, knowing the data analysis and interpretation could take months or years.

Voyager 1 does not have a working plasma sensor, so scientists needed a different way to measure the spacecraft's plasma environment to make a definitive determination of its location. A coronal mass ejection, or a massive burst of

solar wind and magnetic fields, that erupted from the sun in March 2012 provided scientists the data they needed. When this unexpected gift from the sun arrived at Voyager 1's location 13 months later, the plasma around the spacecraft began to vibrate like a violin string. On April 9, Voyager 1's plasma wave instrument detected the movement. The pitch of the oscillations helped scientists determine the density of the plasma. The particular oscillations meant the spacecraft was bathed in plasma more than 40 times denser than what they had encountered in the outer layer of the heliosphere. Density of this sort is to be expected in interstellar space.

The plasma wave science team reviewed its data and found an earlier, fainter set of oscillations in October and November 2012. Through extrapolation of measured plasma densities from both events, the team determined Voyager 1 first entered interstellar space in August 2012.

"We literally jumped out of our seats when we saw these oscillations in our data—they showed us the spacecraft was in an entirely new region, comparable to what was expected in interstellar space, and totally different than in the solar bubble," Gurnett said. "Clearly we had passed through the heliopause, which is the long-hypothesized boundary between the solar plasma and the interstellar plasma."

The new plasma data suggested a timeframe consistent with abrupt, durable changes in the density of energetic particles that were first detected on Aug. 25, 2012. The Voyager team generally accepts this date as the date of interstellar arrival. The charged particle and plasma changes were what would have been expected during a crossing of the heliopause.

"The team's hard work to build durable spacecraft and carefully manage the Voyager spacecraft's limited resources paid off in another first for NASA and humanity," said Suzanne Dodd, Voyager project manager, based at NASA's Jet Propulsion Laboratory, Pasadena, Calif. "We expect the fields and particles science instruments on Voyager will continue to send back data through at least 2020. We can't wait to see what the Voyager instruments show us next about deep space."

Voyager 1 and its twin, Voyager 2, were launched 16 days apart in 1977. Both spacecraft flew by Jupiter and Saturn. Voyager 2 also flew by Uranus and Neptune. Voyager 2, launched before Voyager 1, is the longest continuously operated spacecraft. It is about 9.5 billion miles away from our sun.

Voyager mission controllers still talk to or receive data from Voyager 1 and Voyager 2 every day, though the emitted signals are currently very dim, at about 23 watts—the power of a refrigerator light bulb. By the time the signals get to Earth, they are a fraction of a billion-billionth of a watt. Data from Voyager 1's instruments are transmitted to Earth typically at 160 bits per second, and captured by 34- and 70-meter NASA Deep Space Network stations. Traveling at the speed of light, a signal from Voyager 1 takes about 17 hours to travel to Earth. After the data are transmitted to JPL and processed by the science teams, Voyager data are made publicly available.

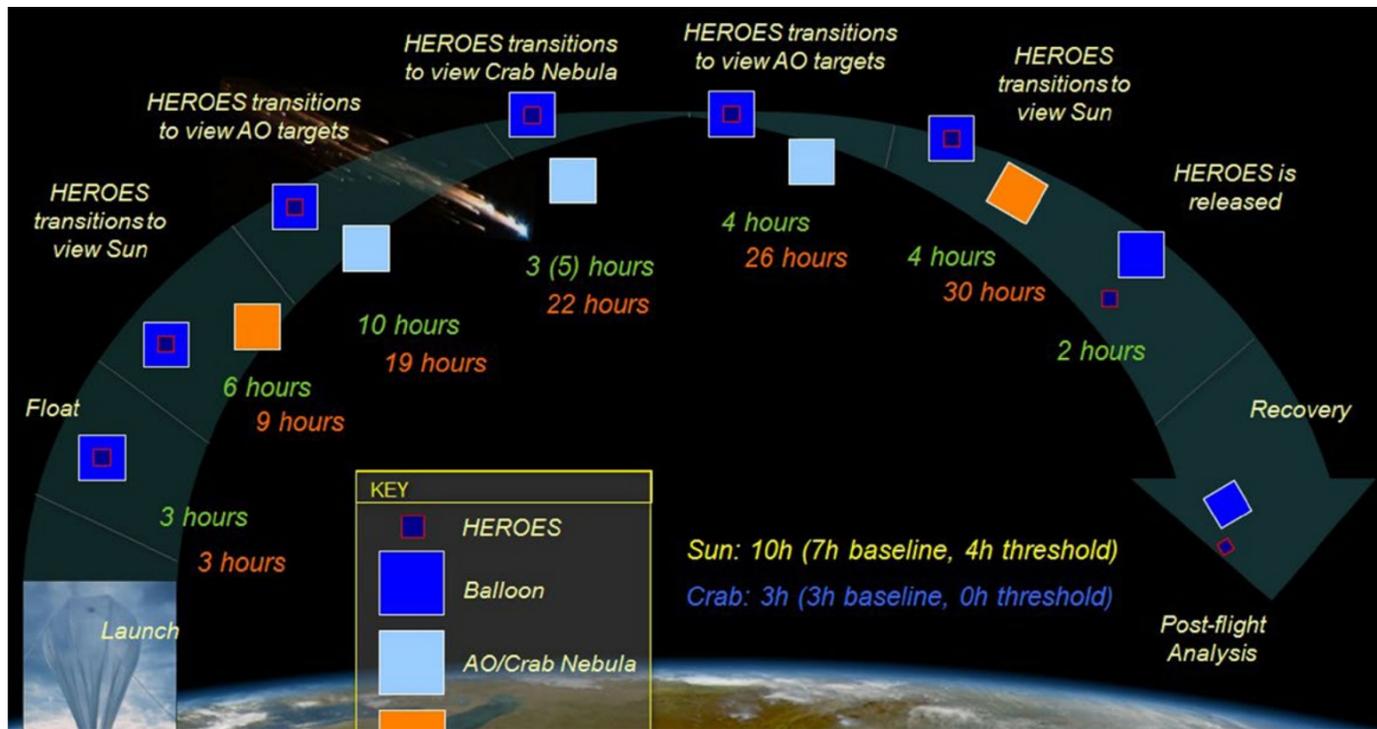
"Voyager has boldly gone where no probe has gone before, marking one of the most significant technological achievements in the annals of the history of science, and adding a

new chapter in human scientific dreams and endeavors," said John Grunsfeld, NASA's associate administrator for science in Washington. "Perhaps some future deep space explorers will catch up with Voyager, our first interstellar envoy, and reflect on how this intrepid spacecraft helped enable their journey."

Scientists do not know when Voyager 1 will reach the undisturbed part of interstellar space where there is no influence from our sun. They also are not certain when Voyager 2 is expected to cross into interstellar space, but they believe it is not very far behind.

[JPL](#) built and operates the twin Voyager spacecraft. The Voyagers Interstellar Mission is a part of NASA's Heliophysics System Observatory, sponsored by the Heliophysics Division of NASA's Science Mission Directorate in Washington. NASA's Deep Space Network, managed by JPL, is an international network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe. The network also supports selected Earth-orbiting missions. ■

Above: This artist's concept depicts NASA's Voyager 1 spacecraft entering interstellar space, or the space between stars. Interstellar space is dominated by the plasma, or ionized gas, that was ejected by the death of nearby giant stars millions of years ago. The plasma exhausted by our sun, known as the solar wind, dominates the environment inside our solar bubble. Image credit: NASA/JPL-Caltech



An innovative, dual solar/space-imaging project, jointly developed by researchers at two NASA field centers, is targeted for launch in mid-September.

The High Energy Replicated Optics to Explore the Sun project is a joint effort to fly a powerful X-ray telescope high into Earth's atmosphere. During the day, it will study solar flares, providing new insight into the way the sun's magnetic energy functions. At night, the telescope's eye will turn outward to the stars, observing a variety of astrophysical targets.

Planned and developed over a period of 15 months by a combined team of solar scientists and astrophysicists at NASA's Marshall Space Flight Center in Huntsville, Ala., and Goddard the scientific balloon carrying HEROES is set to launch from the Ft. Sumner, N.M., test site managed by the Columbia Scientific Balloon Facility of Palestine, Texas. HEROES is expected to fly to an altitude of approximately 25 miles, well into Earth's stratosphere.

The HEROES project is an advanced version of NASA's successful [High Energy Replicated Optics](#) telescope first flown to the upper atmosphere by Marshall researchers in 2001 to detect distant X-ray sources in space. HEROES will significantly modify the original high-flying imager with a number of upgrades, most notably an innovative targeting technology dubbed the Solar Aspect System. Developed at Goddard, this sophisticated, new pointing technology will enable scientists to aim HEROES with a high degree of precision, targeting specific points on the sun to obtain high-resolution images and spectroscopic data. When the

sun sets on HEROES, the telescope will use its star camera to target and document additional X-ray sources overnight.

The cross-center NASA team, led by co-principal investigators Jessica Gaskin at Marshall and Steven Christe at Goddard, is currently prepping the instrument and assessing mission specifications for next week's targeted launch of HEROES. Both centers have more than 35 years of experience in flying high-altitude test balloons, plus decades of experienced NASA leadership in scientific research and spacecraft development, integration, test and launch.

"HEROES will provide the most sensitive hard X-ray observations of the sun captured to date, and will pave the way for this technology to be used on a future satellite mission," Christe said.

"We're equally proud that this effort brings together the capabilities and expertise of NASA's Heliophysics and Astrophysics Divisions," Gaskin said. "By successfully integrating our science goals and working together to develop and fly the instrument we're using to achieve them, we hope to demonstrate how NASA can cut costs, combine resources and dramatically improve the return on its investment across all the extraplanetary sciences." ■

Above: Diagram of an example flight profile is shown. It takes about three hours from launch for the payload to reach float (maximum altitude). HEROES will observe the sun for approximately five hours until it is no longer visible. Astrophysical observations will then take place during the nighttime. Image credit: NASA

## NASA HEROES SET TO LAUNCH BALLOON SOLAR AND SPACE IMAGER

By: Janet Anderson

This summer, a group of interns at NASA's Goddard Space Flight Center in Greenbelt, Md., hoped to make their impact on the center last more than their 10-week term.

Under the Applied Engineering and Technology Directorate, also known as AETD, a team of eight college and three high school students started designing a CubeSat satellite that could one day be launched into space. A CubeSat is a type of miniaturized satellite for space research.

The interns represented the first of a string of several groups that would come in and continue working on the satellite, beginning with design and ending by delivering an actual satellite for flight. Their internships ended on Aug. 9, 2013.

During their time at Goddard, the interns had to conceptualize the mission and provide a preliminary design of the satellite hardware. With Goddard engineers as mentors, the interns followed NASA guidelines and worked hard to develop all of the satellite components—or subsystems—from scratch. The students' skills came from a range of disciplines. Each intern was assigned to work on different satellite subsystems, including optics, thermal, electrical power, systems engineering and satellite communications.

"We threw them into the frying pan," said AETD project manager and lead co-mentor Pat Kilroy. "They had 10 weeks to do what could take NASA a year or so depending on the scope of the project."

The project is part of NASA's CubeSat Launch Initiative, which gives educational institutions an opportunity to fly small satellites—fully-functional, stackable CubeSat units that are 4 inches long and weigh about 3 pounds—to engage students in real life science, technology, engineering and mathematics projects.

This summer's group was responsible for laying the groundwork for the satellite, designing the mission from scratch and presenting their results in a preliminary design review in front of NASA engineers. The interns demonstrated how different mechanical and electrical components of the satellite would work using prototype models.

In addition, the students also featured their results at the intern poster session, a center-wide event held the first week of August. The session allowed interns to showcase their work. The intern team left behind a detailed final report to guide the group that follows them.

Kilroy said the goal was for the interns to make this initial phase comprehensive enough so that the next group of interns could use the design as a foundation for developing the flight hardware.



"They were challenged with the most difficult portion, the front end of a mission," Kilroy said. "It's their baby to pick up and run with it."

In addition to designing the spacecraft bus (infrastructure that houses the instruments) the satellite would be based on, the interns were tasked with designing the instrument the satellite would feature—a tiny hyperspectral imager that uses light waves to determine the chlorophyll content of Earth's plants. Intern Tiara Johnson, an electrical engineering graduate student at Johns Hopkins University, Baltimore, Md., said the challenge was to do all of the work in 10 weeks.

"I think our biggest challenge was the time constraint," Johnson said. "We didn't have that much time, and we had a lot of work to do."

Intern Jeff Sherwood, an electrical engineering student at Central Michigan University, Mount Pleasant, Mich., felt that designing a project for future interns to further develop was a good opportunity to experience how work is actually done at NASA.

"It's nice to get the real-world experience of working on a project with a team of other interns and engineers," Sherwood said. "It's something you can't learn in a classroom." ■

Above: Interns from this past summer's Applied Engineering and Technology Directorate CubeSat project worked with models that helped them design a mission of their own. Image credit: NASA

## NASA INTERNS START WORK ON FUTURE CUBESAT MISSION

By: Claire Saravia

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# LADEE LAUNCH GALLERY



**C**enter: David W. Thompson, Chairman and CEO, Orbital Sciences (left); NASA Administrator Charles Bolden (center) and Mrs. Jaqueline Bolden as they watch the launch of the Minotaur V rocket carrying NASA's Lunar Atmosphere and Dust Environment Explorer on Friday, Sept. 6, 2013 at NASA's Wallops Flight Facility in Virginia. Photo credit: NASA/Carla Cioffi

Left and right bottom: The doors of the gantry support structure are opened to reveal the Minotaur V rocket on Pad 0B at the Mid-Atlantic Regional Spaceport at NASA's Wallops Flight Facility. The Minotaur V launched NASA's Lunar Atmosphere and Dust Environment Explorer. Photo credit: NASA/Carla Cioffi

Left middle: NASA Lunar Atmosphere and Dust Environment Explorer program scientist Sarah Noble talks during a LADEE mission briefing at NASA Headquarters, Thursday, August 22, 2013 in Washington. Photo credit: NASA/Bill Ingalls

Left and right top: NASA's Lunar Atmosphere and Dust Environment Explorer observatory launches aboard the Minotaur V rocket from the Mid-Atlantic Regional Spaceport at NASA's Wallops Flight Facility, Friday, Sept. 6, 2013 in Virginia. Photo credit: NASA/Carla Cioffi

Right middle: NASA Associate Administrator for the Science Mission Directorate, John Grunsfeld, talks during a NASA Social about the Lunar Atmosphere and Dust Environment Explorer mission at the NASA Wallops Flight Facility. Fifty of NASA's social media followers attended a two-day event in support of the LADEE launch. Photo credit: NASA/Carla Cioffi

Click on the center photo to visit the Flickr gallery. ■

# THE GENESIS OF GODDARD

The world is familiar with the origin of the universe, thanks to Goddard's Dr. John Mather, who shared the 2006 Nobel Prize in physics with Dr. George F. Smoot. Very few in our community, however, know about Goddard's own beginnings, which like the universe, started off with a big bang and a lot of drama. All because the Soviets launched a tiny satellite called Sputnik 1 on October 4, 1957.

"I was on the Baltimore-Washington Parkway with my wife one day," said Chesley (Ches) Looney, one of the original employees who worked on the space program since before Goddard even existed. "Half-way between Baltimore and D.C., the radio announcer said that Sputnik had launched. I had tears in my eyes."

Looney was a young engineer at the Naval Research Lab working on Project Vanguard, the United States' response to the Soviet's Sputnik program. Vanguard 1 was to be a six-inch sphere, with mere milliwatts of radio transmitter power. By the summer of 1955, the Army was building and staffing the ground stations, the Navy was working on the system design and electronics and the Air Force was planning the launch. The nucleus of NASA was a few hundred Project Vanguard system design people from the NRL, one of whom was Looney.

The International Council of Scientific Unions' International Geophysical Year was from July 1, 1957, to December 31, 1958. When the IGY began, the Smithsonian was relying on a visual tracking system using telescopes. NRL's Project Vanguard, with the Bendix Corporation, designed and built an electronic satellite tracking system, called "Minitrack" for "minimum weight tracking system." Minitrack included precise timing systems and electronics using NRL-designed interferometer antenna systems and instrumentation. The Army Map Service installed the new satellite tracking ground stations at ten locations around the world.

The country suffered another surprise almost immediately. As part of IGY, both the U.S. and the U.S.S.R had agreed to use an electronic satellite tracking system that worked at 108 MHz. Sputnik used 20 and 40 MHz.

"The Russians misled us. We couldn't track Sputnik when it launched. But it only took us a week to build the necessary conversion gear. It was one of the worst weeks we ever had," Looney said.

Once the Soviets launched Sputnik 1, the race then turned to one between the Army and the Navy, as represented by the NRL. The Army won, launching Explorer 1 on January 31, 1958. NRL was close behind, launching Vanguard 1 on March 17, 1958. Their consolation was that the Army used

the brute force of a Saturn rocket to launch Explorer 1, while the Navy finessed their launch using a more precise vehicle.

"After Sputnik, the Vanguard people felt intense rage that the Russians had lied, followed by disappointment that the Army had launched a satellite before the Navy," said Looney. "But after all that emotion, we buckled down and got the work done."

The U.S. decided to consolidate the Vanguard effort into what became Goddard. The Agricultural Research Center donated the original land except for the Visitor Center, which was the broadcasting station of the National Bureau of Standards. The national urgency by 1959 was such that Project Vanguard moved to what was then called Greenbelt Space Flight Center before buildings numbered one, two and three were even finished. Looney remembers when Mrs. Robert Goddard came for the dedication held outside near Building 1. It was a gloomy, sleety day. But there was still a crowd.



According to Looney, the manned flight effort started at Goddard. Yellow brick was used to highlight Building 8 because it was intended to house human spaceflight until Lyndon Johnson became president and moved human spaceflight to his home state of Texas.

As soon as the frequency conversion equipment was designed and built, teams were sent to install the new equipment at the tracking stations.

Looney was sent to Peru and Chile with the equipment for stations in those countries. In Peru, reporters swarmed Looney, then still a young engineer, and the other tracking station personnel.

"I'm still very proud of our tracking system. It could determine location to within a fraction of an arc-second. The state-of-the-art, low-noise receivers made possible receiving and data handling systems provided good signal-to-noise ratios from the faint satellite signals as the satellites passed over the new tracking stations," said Looney.

Looney decided to become an engineer when he was 13-years-old. Science fiction was always his inspiration. He began reading science fiction in the 1940s, before science fiction was considered a known genre. He has been in the trenches of the space program since before Goddard was established. Now, at 85, he remains just as enthusiastic.

"What I read seemed so real. Time travel? No problem. All the pleasures and disappointments of my career come back to science fiction. And that's how it all started," said Looney.

Center: Looney still hard at work at Goddard. Photo credit: NASA/Goddard/Kevin McLaughlin