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## Eruptions Evicted: Anti-geyser Testing Completed for SLS Liquid Oxygen Tank

*By Megan Davidson*

Goodbye, geysers! NASA engineers have successfully finished anti-geyser testing for the liquid oxygen tank that will help fuel the agency's new rocket, the Space Launch System, on the journey to Mars.

More than 120 hours of anti-geyser testing have been completed on a full-scale, 40-foot replica of the SLS liquid

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*NASA and Boeing engineers conduct anti-geyser testing and monitor data from those tests in a control room at the Marshall Center. (NASA/MSFC)*

## NASA Spacecraft Returns New Images of Pluto En Route to Historic Encounter

NASA's New Horizons spacecraft returned its first new images of Pluto on Feb. 4, as the probe closes in on the dwarf planet. Although still just a dot along with its largest moon, Charon, the images came on the 109th birthday of Clyde Tombaugh, who discovered the distant icy world in 1930.

"My dad would be thrilled with New Horizons," said Clyde Tombaugh's daughter Annette Tombaugh. "To actually see the planet that he had discovered, and find out more about it

-- to get to see the moons of Pluto -- he would have been astounded. I'm sure it would have meant so much to him if he were still alive today."

New Horizons was more than 126 million miles (nearly 203 million kilometers) away from Pluto when it began taking images. The new images, taken with New Horizons' telescopic Long-Range Reconnaissance Imager on Jan. 25 and Jan. 27, are the first acquired during the spacecraft's 2015 approach to the Pluto system, which

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## Anti-geyser Testing *Continued from page 1*

oxygen tank feed system -- which will be housed in the rocket's core stage -- at one of the test stands at NASA's Marshall Space Flight Center. The core stage, towering more than 200 feet tall with a diameter of 27.5 feet, will store cryogenic liquid hydrogen and liquid oxygen that will feed the vehicle's RS-25 engines.

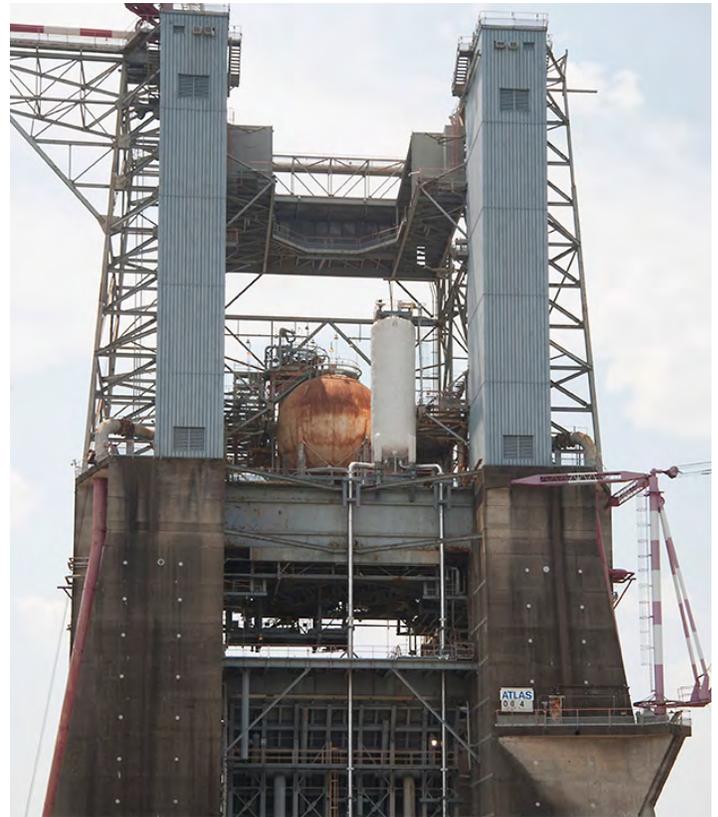
"Geysering occurs when heat enters the liquid oxygen feed system, causing the liquid to boil and form large oxygen gas bubbles that rapidly expel," said Chad Bryant, propulsion manager in the Stages Office at Marshall, where the SLS Program is managed for the agency. "This rapid expulsion of boiling liquid can momentarily displace large volumes of heavy liquid that crash back down, causing a damaging hammer effect on the system.

"One of the largest risks with a liquid oxygen feed system of this scale is the potential of creating a geyser -- that's why this kind of testing is so important," he added. "This gives us the confidence that the operations we have in place for propellant loading, conditioning and draining will successfully suppress geysers in the system during flight vehicle operations."

Those operations include using helium. The system is filled and thermally conditioned by pumping liquid oxygen up the engine feed lines and into the tank, allowing heat to escape up and out the top of the tank vent. As the liquid level rises in the tank, helium is injected into the feed lines, introducing fluid circulation throughout the liquid oxygen system. This circulation is the key to maintaining uniform fluid temperature and eliminating localized propellant heating. "We've used enough liquid oxygen on the test article to fill the SLS oxygen tank eight times -- it's very thorough testing," Bryant said.

Data from the test series will be used in the development and demonstration of the liquid oxygen procedures for SLS core stage green run operations at NASA's Stennis Space Center, and the first flight of the rocket from the agency's Kennedy Space Center. Green run testing of the SLS core stage is the first time the RS-25 engines are assembled into a single configuration with the core stage and fired at nearly full power.

"Anti-geyser testing provided valuable insights into system-specific behaviors and data for model validation," said Jacob Parton, anti-geyser test conductor. "Building the test article had its challenges,



*A full-scale replica of the SLS liquid oxygen tank feed system is set up for anti-geyser testing on one of Marshall's test stands. (NASA/MSFC/David Olive)*

but testing went quite well. The NASA and Boeing teams did a fantastic job."

The Boeing Company of St. Louis is the prime contractor for the SLS core stage, including its avionics. The test series began in August and wrapped up in late January.

Watch a video about the test series [here](#).

The first flight test of the SLS will feature a configuration for a 70-metric-ton (77-ton) lift capacity and carry an uncrewed Orion spacecraft beyond low-Earth orbit to test the performance of the integrated system. As the SLS evolves, it will provide an unprecedented lift capability of 130 metric tons (143 tons) to enable missions even farther into our solar system.

For more information on SLS, visit [here](#).

*Davidson, an ASRC Federal/Analytical Services employee, supports the Office of Strategic Analysis & Communications.*

## NASA Representatives Thank Conrad Shipyard Employees

The Pegasus barge, used to carry the space shuttle external tanks, has undergone recent modifications at Conrad Shipyard in Morgan City, Louisiana, to allow it to transport the large core stage of the Space Launch System. SLS is NASA's new heavy-lift rocket that will carry future explorers to deep space. NASA astronaut Steve Bowen, center, and NASA representatives were on hand Feb. 5 to thank Conrad employees for their work to renovate the barge, which is near completion. From left, Steve Doering, director of Center Operations for NASA's Marshall Space Flight Center; Mike Kynard, deputy director of NASA's Michoud Assembly Facility; Dan Conrad, senior vice president of Conrad Shipyard; Bowen; Johnny Conrad, president and CEO of Conrad Shipyard; Teresa Vanhooser, deputy director of Marshall; Todd May, SLS program manager; and Malcolm Wood, Michoud's deputy chief operating officer. (NASA/Eric Bordelon)



## New Horizons *Continued from page 1*

culminates with a close flyby of Pluto and its moons on July 14.

“This is our birthday tribute to Professor Tombaugh and the Tombaugh family, in honor of his discovery and life achievements -- which truly became a harbinger of 21st century planetary astronomy,” said Alan Stern, New Horizons principal investigator at the Southwest Research Institute in Boulder, Colorado. “These images of Pluto, clearly brighter and closer than those New Horizons took last July from twice as far away, represent our first steps at turning the pinpoint of light Clyde saw in the telescopes at Lowell Observatory 85 years ago, into a planet before the eyes of the world this summer.”

Over the next few months, LORRI will take hundreds of pictures of Pluto, against a starry backdrop, to refine the team's estimates of New Horizons' distance to Pluto. As in these first images, the Pluto system will resemble little more than bright dots in the camera's view until late spring. However, mission navigators can still use such images to design course-correcting engine maneuvers to direct the spacecraft for a more precise approach. The first such maneuver based on these optical navigation images is scheduled for March 10.

“Pluto is finally becoming more than just a pinpoint of light,” said Hal Weaver, New Horizons project scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. “LORRI has now resolved Pluto, and the dwarf planet will continue to grow larger and larger in the images as New Horizons

spacecraft hurtles toward its targets. The new LORRI images also demonstrate that the camera's performance is unchanged since it was launched more than nine years ago.”

Closing in on Pluto at about 31,000 mph, New Horizons already has covered more than 3 billion miles since it launched on Jan. 19, 2006. Its journey has taken it past each planet's orbit, from Mars to Neptune, in record time, and it is now in the first stage of an encounter with Pluto that includes long-distance imaging as well as dust, energetic particle and solar wind measurements to characterize the space environment near Pluto.

“The U.S. has led the exploration of the planets and continues to do so with New Horizons,” said Curt Niebur, New Horizons program scientist at NASA Headquarters. “This mission will obtain images to map Pluto and its moons better than has ever been achieved by any previous planetary mission.”

APL manages the New Horizons mission for NASA's Science Mission Directorate in Washington. Alan Stern, of SwRI, is the principal investigator and leads the mission. SwRI leads the science team, payload operations and encounter science planning. New Horizons is part of the New Frontiers Program, managed by NASA's Marshall Space Flight Center. APL designed, built and operates the spacecraft.

To view the Pluto image online and see the mission timeline for upcoming images, visit [here](#) and [here](#).

# RS-25 Testing: Behind the Scenes Engine Teams Meet Challenges

By Martin Burkey

The smoke and fire of a rocket engine test at NASA's Stennis Space Center is a routine sight to the space community. But behind the scenes in late 2014, the situation wasn't routine as the team worked to ready both the engine and the test stand for the world's most powerful rocket. When the test went the scheduled 500 seconds without a hitch Jan. 9, it would be a success on several levels, managers say.

The RS-25, formerly known as the space shuttle main engine, had established a solid reputation over 30 years, 135 shuttle missions and more than a million seconds of test and flight time. NASA called this workhorse out of retirement for the Space Launch System, designed for unprecedented new missions of exploration beyond Earth's orbit.

But the last test of a shuttle main engine at Stennis was in 2009 as the Shuttle Program headed toward retirement. After that, the A-1 stand was modified for other engine programs. For SLS, the stand would have to be refurbished, and the RS-25 would have to literally pass a trial by fire to certify it flightworthy of the new rocket's particular operating conditions, as well as a new controller and software to replace the outdated shuttle computers.

Overcoming various routine hurdles to complete test stand modifications and development of the new engine controller in 2014, the engine team was ready to make the ground shake again in Mississippi and get SLS off to a hot start in early 2015 with the first of 10 planned engine test firings.

But another challenge appeared before the traditional holiday break last December. Like its shuttle predecessor, the new SLS controller uses two redundant data channels to compare and reject false readings by the engine's pressure, temperature, speed and other sensors -- basically two heads are better than one. But the channels were interfering with each other in tests, resulting in unallowable propellant control valve oscillation in the engine.

After analysis and open discussion -- along with years of knowledge about the RS-25 -- the team decided to disable one channel, and to go forward with a preparatory chill test and the 500-second hotfire test with only one decision-making channel.



*The RS-25 engine fires up for a 500-second test Jan. 9 at Stennis. (NASA/Stennis)*

Although the test objectives were at risk, the engine itself was designed for such a shutdown. Ironically, the potential loss of one channel in flight was an objective for a later test.

Then an unexpected software problem and a looming deadline further complicated the first engine test. The software issue had to be fixed and tested. That cost another day's work in the timeline and came at the end of several long weeks of work for the test crew. The team decided to thoroughly test the software and delay the test 24 hours to allow the test crew to rest.

"We were facing a mandatory test stand shutdown of several weeks for scheduled improvements to the water system," SLS Liquid Engines Office Manager Steve Wofford noted. "Delays also had implications for the construction company engaged to upgrade the test stand, and a commercial program also waiting to test at Stennis."

Working with Stennis and the commercial companies involved, SLS negotiated a delay in the test stand outage. Impressively, Wofford said, those organizations gave the engine team all of the slack days in their schedules to accomplish the important engine test before the test stand outage.

"It was a great example of inter-center team work and cooperation between NASA and the commercial

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## Michoud Assembly Facility Dedicates 'Hero's Way'

Team members at NASA's Michoud Assembly Facility attended a ceremony Feb. 5 honoring members of the NASA family who have lost their lives in the quest of space exploration. The ceremony also dedicated the new "Hero's Way" corridor. The indoor corridor, lined with space shuttle mission patches and commemorative flags, runs across the north side of Building 103, Michoud's main manufacturing facility. The hallway will be a reminder for employees and visitors to remember and honor those brave men and women who have made space exploration possible. (NASA/MAF)



## Marshall Center, Team Redstone Host 14th Annual 'Adventures in Engineering' Event for Area High School Students



On Feb. 4, NASA's Marshall Space Flight Center and the U.S. Army Redstone Arsenal hosted more than 400 high school juniors during the 14th annual "Adventures in Engineering" event. Twenty-seven schools throughout North Alabama and Southern Tennessee participated. The event is designed to encourage students to pursue careers in science, technology, engineering and mathematics – the STEM fields. Students visited both Marshall and Army facilities to learn about current research, view technical hardware and speak with scientists and engineers. During the Marshall tour, students learned about the Environmental Control & Life Support Systems in Building 4755; friction stir welding in Building 4755; and the Orion spacecraft in Building 4205, among other topics. The event was a collaborative effort by Marshall, the Army Space and Missile Defense Association, National Defense Industrial Association and Calhoun Community College in Decatur, Alabama. (NASA/MSFC/Fred Deaton)

## RS-25 Testing *Continued from page 4*

program," Wofford said. "I told our team that the engine ran on liquid hydrogen and oxygen and a lot of hard work, dedication, and attention to detail from everyone involved."

The team's decision to take some reasonable, calculated risk and press on with the test with one data channel down helped keep the engine program on track, but it had larger implications, said Bill Hill, deputy associate administrator for Exploration Systems Development at NASA.

"Risk management and willingness to carefully assess, understand and accept a bit of elevated technical risk in order to achieve an important objective is something we want to encourage," Hill said.

*Burkey, an ASRC Federal/Analytical Services employee, supports the Office of Strategic Analysis & Communications.*

# New Images from New Horizons Spacecraft Featured On This Week @NASA

New images of the dwarf planet Pluto -- taken by NASA's New Horizons spacecraft -- were featured in the latest edition of "[This Week @NASA](#)," a weekly video program broadcast nationwide on NASA-TV and posted online.

The images of Pluto and its largest moon Charon were taken using the spacecraft's telescopic Long-Range Reconnaissance Imager on Jan. 25 and Jan. 27 from more than 126 million miles away. The images also will play a critical role in navigating the spacecraft as it covers the remaining 135 million miles to Pluto.

The images were released on Feb. 4, the 109th birthday of late astronomer Clyde Tombaugh, who first spotted the small planet in 1930. New Horizons will make a close flyby of Pluto and its moons on July 14.

The Johns Hopkins University's Applied Physics Laboratory manages the New Horizons mission



for NASA's Science Mission Directorate. Southwest Research Institute leads the science team, payload operations, and encounter science planning. The New Horizons spacecraft is part of NASA's New Frontiers program managed by the Marshall Center.

View this and previous episodes at "[This Week @NASA](#)" or at <https://www.youtube.com/user/NASAtelevision>.

## Obituaries

**Harry Gordon Harber**, 88, of Cullman, Alabama, died Jan. 11. He retired from the Marshall Center in 1984 as an aerospace engineer.

**Alva W. Deaton**, 79, of Owens Cross Roads, Alabama, died Jan. 12. He retired from the Marshall Center in 1993 as an aerospace engineer. He is survived by his wife, Anita Kathleen Cummings Deaton.

**Robert R. Belew**, 91, of Huntsville, died Jan. 15. He retired from the Marshall Center in 1986 as an aerospace engineer.

**Fred Manley**, 86, of Guntersville, Alabama, died Jan. 31. He retired from the Marshall Center in 1990 as a facilities and property utilization specialist.

**Esther Thomas Boyer**, 95, of Huntsville, died Feb. 1. She retired from the Marshall Center in 1974 as a secretary.