The Marshall Star

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Getting to Know You, Rocket Edition: Interim Cryogenic Propulsion Stage

By Megan Davidson

Some elements of a rocket can be familiar, like the boosters and engines. But there are several important parts on NASA's new rocket, the Space Launch System, that may be less widely known. Case in point? The interim cryogenic propulsion stage.

If the SLS was dissected, the ICPS lies just below the Orion capsule, at the top of the SLS. The ICPS is a liquid oxygen/liquid hydrogen-based system.

*See **ICPS** on page 2*

Artist concept of the Orion spacecraft. The ICPS will boost the Orion to the correct altitude and trajectory needed to send the spacecraft around the moon in order to check out vital systems during the initial test flights. (NASA)

Marshall's Surface Crack Analysis Design is Co-Winner for 2014 Software of the Year Award

Two NASA software design teams have received the agency's prestigious Software of the Year Award for 2014. A Marshall developed software tool, which looks into nonlinear surface crack analysis to prevent critical structure failures is one of the winners. The other winner, developed by NASA's Ames Research Center, is software used to predict structural loads for aircraft and space vehicles that will react to high temperatures in a variety of flight simulated conditions.

The Tool for Analysis of Surface Cracks was developed by Phillip Allen, a materials engineer and structural analyst at NASA's Marshall Space Flight Center. The software provides a more thorough understanding of surface crack material fracture toughness -- essential to prevent failures -- for safer aerospace vehicles and structures. Surface cracks are the most common defect found in engineering structures. The results of the surface crack fracture

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Construction Underway on SLS Test Stand at Marshall

Crews pour concrete and embed anchor rods Oct. 17 to stabilize a new, 215-foot test stand at NASA's Marshall Space Flight Center. Test Stand 4693 will be used for structural loads testing on the liquid hydrogen tank for the core stage of NASA's Space Launch System. The core stage, towering more than 200 feet tall, will store cryogenic liquid hydrogen and liquid oxygen that will feed the vehicle's RS-25 engines. SLS will be the most powerful rocket ever built for deep space missions, including to an asteroid and ultimately Mars.

The 4693 structure -- being built on the foundation of the stand where the Saturn V F-1 engine was tested -- will have a twin-tower configuration and be made with 2,150 tons of steel. The liquid hydrogen tank will be placed in the stand vertically, and be loaded with liquid nitrogen for stress testing. A second test stand also is under construction at the Marshall Center and will be used to test the liquid oxygen tank. The stands are on track to being completed in 2015. For more information on the test stands, click here. (NASA/MSFC)

ICPS *Continued from page 1*

On the first test mission of Orion and SLS together, called Exploration Mission-1, the ICPS will give Orion the big push needed to fly beyond the moon before the spacecraft returns to Earth. For later long-duration missions in deep space, this interim stage will be replaced with a more powerful upper stage on SLS needed to carry crews and their spacecraft farther than ever before, including to an asteroid and ultimately Mars.

Orion will serve as the exploration vehicle that will carry the crew to space; provide emergency abort capability; sustain the crew during the space travel; and provide safe re-entry from deep space return velocities.

For the ICPS, The Boeing Co. will modify its existing Delta Cryogenic Second Stage, used on United Launch Alliance's Delta IV family of launch vehicles. It will be powered by an Aerojet Rocketdyne RL-10B2 engine -- also currently used on the Delta Cryogenic Second Stage.

"Boeing's Delta Cryogenic Second Stage will need relatively minor modifications to be fully compliant with SLS requirements, which will keep us on schedule for the first two flights," said Chris Calfee, ICPS project manager at NASA's Marshall Space Flight Center. Marshall manages the SLS Program for the agency.

Those modifications include lengthening the liquid hydrogen tank, adding hydrazine bottles for attitude control and making some minor avionics changes to meet the design parameters and performance characteristics as needed by NASA to meet the flight objectives.

"Affordability is key when a rocket as big and powerful as the SLS is needed for sustainable deep space exploration," said Steve Creech, assistant SLS Program manager for strategy and partnerships at Marshall. "By using existing hardware and technology, we aim to create a multipurpose vehicle that can demonstrate the capabilities of this flexible system on early mission objectives."

NASA's baseline plan is to use an ICPS for SLS on the uncrewed Exploration Mission-1, with an option for a second ICPS that may be used for a crewed Exploration Mission-2. NASA continues to examine its timeline for integrating an upper stage and evolving SLS toward a 130-metric-ton (143-ton) version that will send humans to Mars.

NASA recently signed a contract agreement with Boeing for the ICPS – completing all definitization contracts for the major SLS elements. The interim cryogenic propulsion stage is managed under the SLS Program by the Spacecraft and Payload Integration and Evolution Office at Marshall.

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

Former Marshall, NASA Leaders Celebrate von Braun Honoree

Marshall Space Flight Center Director Patrick Scheuermann, far right, joins four former Marshall Center leaders and a former NASA administrator to honor Gen. John E. Hyten, second from right, vice commander of the U.S. Air Force Space Command, who was awarded the Dr. Wernher von Braun Flight Trophy Oct. 29 during the 7th annual Wernher von Braun Memorial Symposium in Huntsville. Joining the ceremony were, from left, Thomas "Jack" Lee, director of Marshall from 1989-94; Arthur Stephenson, center director from 1998-2003; Arthur "Gene" Goldman, Marshall acting director in 2012; David King, Marshall director from 2003-09; and former NASA Administrator Michael Griffin, who led the agency from 2005-09. The Von Braun Trophy, presented annually by the National Space Club of Huntsville, recognizes individuals for critical, long-term contributions to spaceflight programs and to continued American leadership in rocketry and astronautics. The symposium, sponsored by the American Astronautical Society and organized with the Marshall Center, the University of Alabama in Huntsville and the National Space Club, featured panel discussions with key NASA and industry leaders and updates on the agency's top missions, including the International Space Station, the Orion crew vehicle and the Space Launch System, managed for NASA by Marshall. (NASA/MSFC/Emmett Given)

Software of the Year *Continued from page 1*

toughness tests and fracture analyses ensure safe operation of nearly all of NASA's flight and ground support hardware.

"This software is a landmark achievement because it reduces the costs for the government and numerous companies in many engineering fields that conduct this fundamental analysis to ensure structures are safe," said Marshall Center Director Patrick Scheuermann. "We are pleased to make this valuable contribution and to share in this prestigious NASA award."

Since its release in January 2014, the Tool for Analysis of Surface Cracks has been downloaded more than 500 times and is in use by multiple NASA centers, government contractors, aerospace industries and universities.

The Configuration-Based Aerodynamics software package developed by Jeffrey Bowles and David Kinney from NASA's Ames Research Center, and Loc Huynh of Eloret Corp., in Moffett Field, California, is used to predict how NASA's Crew Exploration Vehicle, America's new spacecraft for human space exploration, and other aerospace designs, will react to high temperatures in a variety of simulated flight conditions.

The Configuration-Based Aerodynamics software has been transferred to U.S. industry, academia and government agencies, and includes more than 50 Software Usage Agreements with major U.S. manufacturers of aircraft, helicopters, launch vehicles and spacecraft.

Every NASA center and facility is invited to participate in the agency's annual Software of the Year competition, which is sponsored by the NASA Chief Engineer, the NASA Chief Information Officer, and the NASA Office of Safety and Mission Assurance. A Software Advisory Panel with representatives from across the agency reviews the entries and recommends winners to the Inventions and Contributions Board.

The competition allows the agency to recognize and appreciate NASA team members who set high standards for significant software that is creative, usable, transferable and possesses inherent quality.

For more information about NASA's Inventions and Contributions Board, visit here.

Astronaut Steven Swanson Presents Expedition 40 Plaque to Space Station Payload Operations Team

Tim Hanby, lead data management coordinator for the science operations team that supported International Space Station Expedition 40, hangs a plaque replicating the Expedition 40 patch at the Payload Operations Integration Center at NASA's Marshall Space Flight Center. NASA astronaut Steven Swanson, right, Expedition 40 commander, presented the plaque to Hanby and the payload operations team he worked with during his stay on the station from March 25 to Sept. 5. Swanson was at Marshall for technical discussions about the experiment operations he and the science operations team performed during his stay in space. The teamwork between the crew and ground teams during Expedition 40 resulted in the crew breaking a record for the number of hours worked -- almost 84 hours -- on science during one week. Station crews spend an average of 35 hours a week setting up and conducting experiments. Ground control teams in Huntsville work with scientists around the globe to operate many experiments that do not require crew attention. To date, more than 1,550 research investigations and student experiments from 82 countries have been completed on the space station. (NASA/MSFC/Emmett Given)

It's Anchors Aweigh on Modifications to NASA's Pegasus Barge

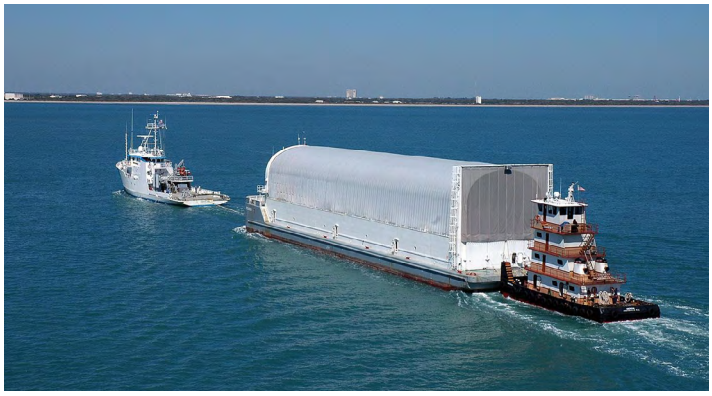
By Megan Davidson

It's anchors aweigh on refurbishments to NASA's Pegasus barge, which will be used to ferry the massive core stage of America's next great ship -- the Space Launch System.

SLS will be the most powerful rocket ever built for deep space missions, including to an asteroid and ultimately to Mars. The core stage, towering more than 200 feet tall with a diameter of 27.6 feet, will store cryogenic liquid hydrogen and liquid oxygen that will feed the vehicle's RS-25 engines.

The core stage is made up of five parts: the engine section, liquid hydrogen tank, intertank, liquid oxygen tank and forward skirt. Work is currently underway at NASA's Michoud Assembly Facility to build the core stage using state-of-the-art welding techniques and machinery.

During the space shuttle era, Pegasus was used to carry shuttle external tanks and other hardware from Michoud to NASA's Kennedy Space Center.



NASA's Pegasus barge, shown transporting the external tank during the space shuttle era, is now undergoing major modifications required to carry the core stage of the SLS for testing and launch. (NASA)

"Modifications were needed to the barge due to the sheer size of the SLS -- which is more than 50 feet taller than the shuttle, and will launch more than three times as much weight into space," said Alan Murphy, team lead for the Pegasus project at NASA's Marshall Space

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Marshall Cost Engineer Juan Carlos Atayde Receives NASA Cost Estimator of the Year Award

By Jena Rowe

Juan Carlos Atayde, cost lead for the Space Launch System Stages Office at NASA's Marshall Space Flight Center, was recently presented with the NASA Cost Estimator of the Year Award. This award recognizes individuals who have excelled in the technical merits of cost estimating at a specific center or at NASA Headquarters.

"JC deserves this award because of his hard work, dedication and innovation," said Andy Prince, manager of Marshall's Engineering Cost Office. "He believes strongly in NASA's mission and wants to make sure NASA's Space Launch System has the best cost estimates possible."

Atayde regularly works with engineers and program managers to gather information and define the requirements necessary for developing the SLS core stage. Once the input data is gathered, an accurate cost estimate can be produced.

"I like the fact that my job allows me to interact with people who are true experts in their field," said Atayde. "I have learned a lot of amazing things and I have always wanted a job that wasn't routine. This is it. I do different things constantly with different people."

Cost estimation for a cutting-edge program such as SLS does not come without its hurdles. But with those hurdles come opportunities for innovation. "Cost estimates are usually developed at a very top level," said Atayde. "For this project, we have had to formulate estimates that are very detailed as well as provide different perspectives of how to look at impacts." While developing the estimate for the SLS core stage, Atayde established new applications for the PRICE TruePlanning tool to solve complex estimating problems.

As a result of Atayde's efforts, the SLS Stages Office has a detailed, government-derived cost estimate that is being used in negotiations to establish a fair and affordable price for SLS development. The estimate is also being updated and modified to provide useful information for effective cost management of SLS.

"I am proud to say that I work at NASA and that I am a part of the SLS workforce," said Atayde. "This project has allowed me to formulate and look at cost estimates/data differently and to start thinking of new ways to continue the program's success."

Rowe, an ASRC Federal/Analytical Services employee and Marshall Star editor, supports the Office of Strategic Analysis & Communications.

Speaker Shares Challenges, Hopes of Disabled with Marshall Team during National Disability Employment Awareness Program

Milton Anthony, a local speaker who faces adversity every day, addressed team members at NASA's Marshall Space Flight Center during a Disability Employment Awareness program Oct. 29. Anthony shared his personal challenges with his disabilities and a message of resilience and hope.

Anthony was nearly killed in 1982 following a bombing by a rival motorcycle gang. The attempt on his life left him completely blind with ocular prosthetics, severely hearing impaired and a triple amputee. This life-changing event compelled him to reverse the course of his life in a positive direction.

This event was sponsored by the Office of Diversity and Equal Opportunity.

From left, Loucious Hires, director of Marshall's Office of Diversity & Equal Opportunity, and Marshall Associate Director Robin Henderson present Milton Anthony with a certificate of appreciation. (NASA/MSFC/Fred Deaton)

Pegasus Barge *Continued from page 4*

Flight Center. "The core stage is 59 feet longer and more than 500,000 pounds heavier, including the ground support equipment, than the space shuttle external tank. The modification work is on schedule, and we look forward to seeing the barge back in the water for a new era of exploration."

Pegasus -- housed since 2011 at NASA's Stennis Space Center -- is now docked at Conrad Shipyard LLC in Morgan City, Louisiana. Conrad will perform all necessary modifications and refurbishments to ensure the restored vessel meets American Bureau of Shipping standards, including load line certification, or verification of the barge's legal loading limit to safely maintain buoyancy during water travel.

The Corps of Engineers' Marine Design Center in Philadelphia, Pennsylvania -- utilizing the engineering expertise of Bristol Harbor Group of Bristol, Rhode Island -- is performing the architecture and engineering work for the barge modification, as well as managing the Conrad contract.

Conrad crews are currently building a new, 165-foot center section for the barge. The modifications will bring the total length of the barge from 260 feet to 310 feet -- a little more than the length of a football field. A 115-foot center section of the existing barge will be removed and the new piece installed later this fall. Work is expected to be completed in early 2015.

Once the modifications are complete, the Pegasus will be stationed at Michoud for operational readiness and maintenance. The first planned set of voyages for the Pegasus will be from Michoud to the Marshall Center to deliver the core stage structural test articles for testing to ensure that these huge structures can withstand the incredible stresses of launch.

Crews at Conrad Shipyard are building a new, 165-foot section for the Pegasus barge, which will lengthen the vessel from 260 feet to 310 feet. (NASA/Steven Seipel)

The barge also will deliver the flight core stage from Michoud to Stennis, where it will be tested in late 2016 and early 2017 on the B-2 test stand. The core stage will be installed on the stand -- currently undergoing its own modifications -- for propellant fill and drain testing and a hot fire test. Once testing is complete at Stennis, the Pegasus will transport the core stage to Kennedy Space Center for preparation and integration into the SLS flight vehicle in the Vehicle Assembly Building.

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

Orion's First Flight Activities Kick Off with Multi-Center NASA Social

On Dec. 4, Orion will launch atop a Delta IV Heavy rocket from Cape Canaveral Air Force Station's Space Launch Complex for the Orion Flight Test: a two-orbit, four-hour flight. Liftoff is targeted for 6:05 a.m.

For the first time ever, all 10 NASA field centers will participate in a multi-center NASA Social event Dec. 3, previewing the Dec. 4 first flight. NASA's Marshall Space Flight Center is inviting social media users from all over to get a unique, behind-the-scenes look at the diverse work at NASA centers across the country. Each center will be connected to NASA's Kennedy Space Center via a multi-center NASA Television simulcast during its social.

Along with discussing Orion and NASA's Journey to Mars, participants will get to experience the Marshall Center through tours and presentations with scientists, engineers and managers. Marshall team members and the public can follow the Marshall NASA Social on our social accounts: Twitter - @NASA_Marshall, Facebook and Instagram.

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NASA'S Chandra Observatory Identifies Impact of Cosmic Chaos on Star Birth

The same phenomenon that causes a bumpy airplane ride, or turbulence, may be the solution to a long-standing mystery about stars' birth, or the absence of it, according to a new study using data from NASA's Chandra X-ray Observatory.

Galaxy clusters are the largest objects in the universe, held together by gravity. These behemoths contain hundreds or thousands of individual galaxies that are immersed in gas with temperatures of millions of degrees.

This hot gas, which is the heftiest component of the galaxy clusters aside from unseen dark matter, glows brightly in X-ray light detected by Chandra. Over time, the gas in the centers of these clusters should cool enough that stars form at prodigious rates. However, this is not what astronomers have observed in many galaxy clusters.

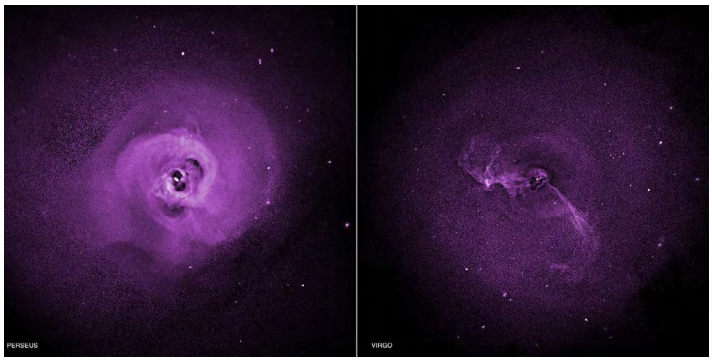
"We knew that somehow the gas in clusters is being heated to prevent it cooling and forming stars. The question was exactly how," said Irina Zhuravleva of Stanford University in Palo Alto, California, who led the study that appears in the latest online issue of the journal Nature. "We think we may have found evidence that the heat is channeled from turbulent motions, which we identify from signatures recorded in X-ray images."

Prior studies show supermassive black holes, centered in large galaxies in the middle of galaxy clusters, pump vast quantities of energy around them in powerful jets of energetic particles that create cavities in the hot gas. Chandra, and other X-ray telescopes, have detected these giant cavities before.

The latest research by Zhuravleva and her colleagues provides new insight into how energy can be transferred from these cavities to the surrounding gas. The interaction of the cavities with the gas may be generating turbulence, or chaotic motion, which then disperses to keep the gas hot for billions of years.

"Any gas motions from the turbulence will eventually decay, releasing their energy to the gas," said co-author Eugene Churazov of the Max Planck Institute for Astrophysics in Munich, Germany. "But the gas won't cool if turbulence is strong enough and generated often enough."

The evidence for turbulence comes from Chandra data



Chandra observations of the Perseus and Virgo galaxy clusters suggest turbulence may be preventing hot gas there from cooling. These new results could answer a long-standing question about how these galaxy clusters keep their enormous reservoirs of hot gas from cooling down to form stars. (NASA/CXC/Stanford/I. Zhuravleva et al)

on two enormous galaxy clusters named Perseus and Virgo. By analyzing extended observation data of each cluster, the team was able to measure fluctuations in the density of the gas. This information allowed them to estimate the amount of turbulence in the gas.

"Our work gives us an estimate of how much turbulence is generated in these clusters," said Alexander Schekochihin of the University of Oxford in the United Kingdom. "From what we've determined so far, there's enough turbulence to balance the cooling of the gas."

These results support the "feedback" model involving supermassive black holes in the centers of galaxy clusters. Gas cools and falls toward the black hole at an accelerating rate, causing the black hole to increase the output of its jets, which produce cavities and drive the turbulence in the gas. This turbulence eventually dissipates and heats the gas.

While a merger between two galaxy clusters may also produce turbulence, the researchers think that outbursts from supermassive black holes are the main source of this cosmic commotion in the dense centers of many clusters.

Marshall manages the Chandra program for NASA's Science Mission Directorate in Washington. The Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, controls Chandra's science and flight operations.

An interactive image, podcast and video about these findings are available here.

Destination Station, Administrator Bolden's Station Connection and SLS Testing Featured on NASA-TV

Multiple events were featured in the latest edition of "This Week @NASA," a weekly video program broadcast nationwide on NASA-TV and posted online. Destination Station, the second in a series of live, interactive panel discussions about cutting-edge technologies tested on the International Space Station, was held Oct. 27 at the U.S. Space & Rocket Center in Huntsville. The forum drew NASA and aerospace leaders to discuss the space station as a test bed for technologies providing benefits to life on Earth, as well as its role in the development of future exploration technologies needed for deep space destinations.

Also during the week, NASA Administrator Charles Bolden visited Marshall's Payload Operations Integration Center, which oversees on-orbit science investigations conducted aboard space station. During the visit, Bolden conducted an in-flight connection with NASA astronauts Butch Wilmore and Reid Wiseman to discuss recent activities on the orbiting laboratory, as well as the completion of recent science investigations. Wilmore – a Mt. Juliet, Tennessee, native assumes command for Expedition 42 in November for five months, while Reid is scheduled to depart the station and return to Earth Nov. 9. Bolden also attended the 7th annual Wernher von Braun Memorial Symposium, where he discussed on-orbit station research and the cutting-edge technologies being tested for Orion and the Space Launch System -- efforts that will support NASA's journey to Mars.

Also featured in this edition were recent wind tunnel tests of a 35-inch-long booster separation model of NASA's Space Launch System, managed by the Marshall Center. The testing -- conducted in Langley Research Center's Unitary Plan Wind Tunnel and at air speeds over 2,400 mph -- will help NASA engineers better understand the aerodynamic forces experienced by real SLS rockets when flying through Earth's atmosphere. The SLS will be the world's most powerful rocket, capable of launching astronauts aboard the Orion spacecraft to deep space destinations.

This and previous episodes of "This Week @NASA" are available for viewing at the NASA-TV YouTube channel.

NASA Social *Continued from page 6*

Updates and information about launch activities and all NASA Social events will be shared on the main NASA and Orion accounts: Twitter (@NASA, @NASASocial, @NASA_Orion), Facebook (NASA, NASA's Orion Spacecraft), and Google+ (NASA).

The Delta IV Heavy rocket will send Orion 3,600 miles above Earth to test the spacecraft's systems most critical to crew safety. After orbiting Earth twice, Orion will reenter Earth's atmosphere at 20,000 miles per hour, generating temperatures near 4,000 degrees Fahrenheit, before it splashes down in the Pacific Ocean.

Orion is being built to send humans farther than ever before, including to an asteroid and Mars. Although the spacecraft will be uncrewed during its December flight, the crew module will be used to transport astronauts safely to and from space on future missions. Orion will provide living quarters for up to 21 days, while longer missions will incorporate an additional habitat to provide extra space.

In the future, Orion will launch on NASA's new heavy-lift rocket, the Space Launch System. More powerful than any rocket ever built, SLS will be capable of sending humans to deep space destinations such as an asteroid and eventually Mars. Exploration Mission-1 will be the first mission to integrate Orion and the SLS.