



ESD

EXPLORATION SYSTEMS DEVELOPMENT

COMBINED MONTHLY HIGHLIGHTS
APRIL 2014



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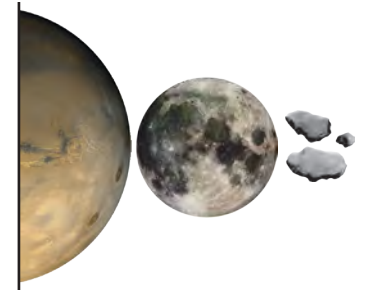
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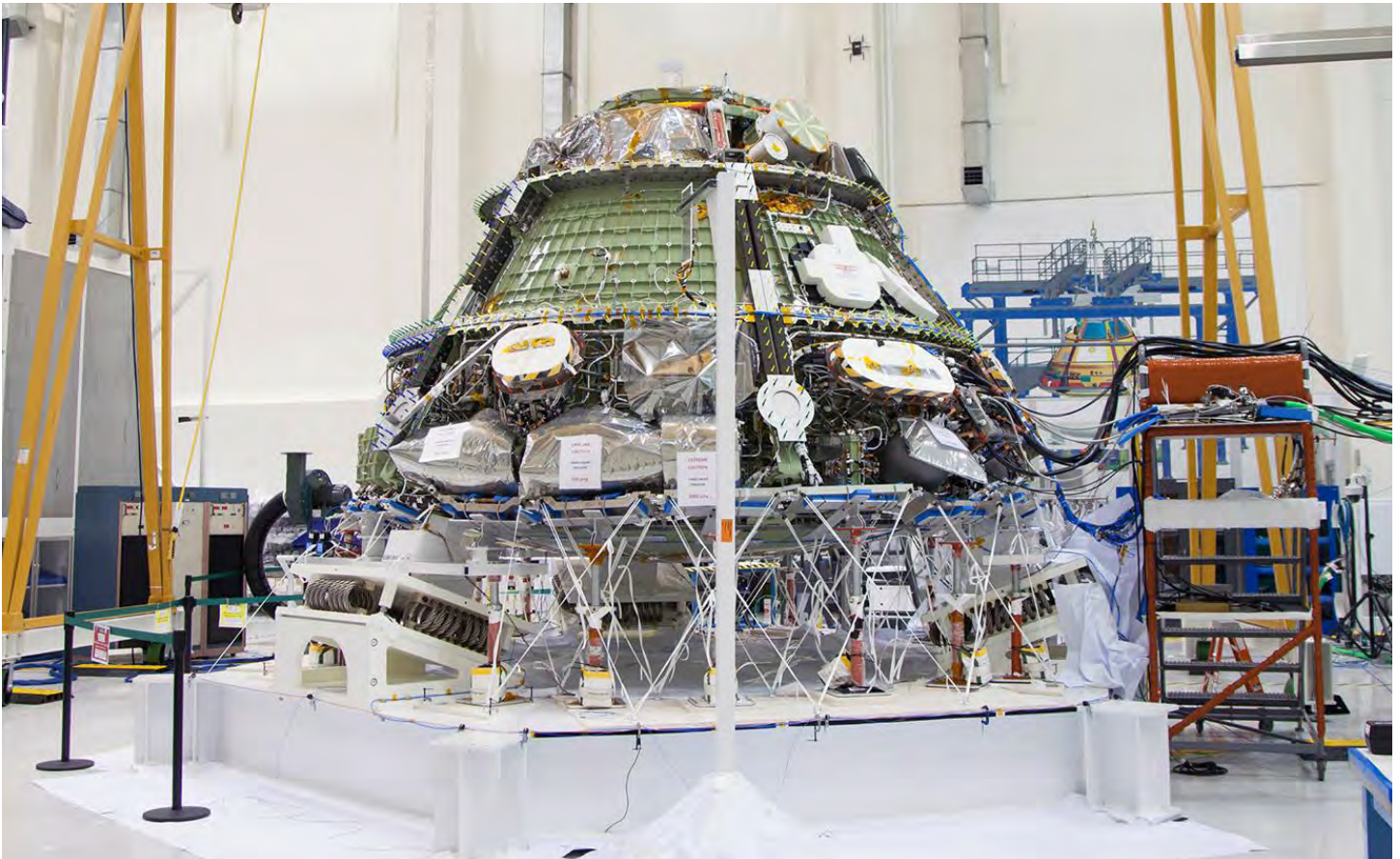
ORION

SPACE LAUNCH SYSTEM

GROUND SYSTEMS DEVELOPMENT & OPERATIONS



Orion team shakes things up



Testing designed to validate Orion's avionics systems and simulate the vibrations NASA's new spacecraft will experience during its first trip to space successfully wrapped up inside the Operations and Checkout Building high bay at NASA's Kennedy Space Center in Florida. The completion of the testing marks another step forward toward Orion's uncrewed flight that will put to the test the spacecraft that will send astronauts to an asteroid and eventually Mars on future missions.

To prepare for the vibration tests, which were conducted April 17-24, a team of NASA and Lockheed Martin engineers and technicians transferred Orion from the

crew module assembly station to a special vibration stand in a portable test chamber.

Accelerometers and strain gages were placed around the crew module in various locations. These were used to measure simulated acceleration and strain levels on Orion's structure.

Two electromagnetic shakers, each capable of up to 4,000 pounds of force, were attached to Orion on opposite sides. Baseline vibration tests began at 5 megahertz and gradually were increased up to about 500 megahertz.

Continued from page 1

After each test run, the shakers were relocated to different points on Orion and systems specialists checked for any changes or abnormalities in the spacecraft's structure.

Before each 30-second test run, Orion's avionics, batteries and electrical systems were powered up and its ammonia and helium tanks were pressurized to 200 psi.

The tests were monitored in a separate control room near the high bay, and the data after each 30-second run was analyzed to check for imperfections or defects and how the crew module performed. A flight simulation team in Firing Room 1 in Kennedy's Launch Control Center monitored Orion during periods of powered-up testing.

Preliminary analysis of the test data confirmed that Orion performed as predicted.

Earlier in the month, testing of Orion's avionics system was conducted at Kennedy. During these tests, engineers activated and sent commands to more than 20 different critical systems installed on the crew module including the pyrotechnics, batteries, thermal control, cameras, guidance and navigation, propulsion, and environmental control life support systems, all while evaluating signal quality, on-board system responses, and data production.

The spacecraft ran for 26 uninterrupted hours during the testing phase.

The tests verified the crew module can route power and send commands that enable the spacecraft to manage its computer system, software and data loads, propulsion valves, temperature sensors and other instrumentation. It also verified that the avionics for Exploration Flight Test-1 are ready to support a successful flight and re-entry of the spacecraft.



Media preview renovated flight control room for NASA's Orion spacecraft

Mission Operations Director Paul Hill spoke to the media as NASA Administrator Charles Bolden and Johnson Space Center Director Ellen Ochoa visited Mission Control on April 10 in the historic White Flight Control Room, which has been newly renovated to support Orion during NASA's deep-space exploration missions.

During the tour, Bolden, Ochoa and Hill also spoke with Jimmy Spivey, the Orion/SLS Manager for the Mission Operations Directorate (pictured below left), about the EFT-1 simulation between NASA and Lockheed Martin control teams where the team flowed recorded Orion data from tests to simulate the mission.

ABC News: bit.ly/1uHm7dX

FOX News: bit.ly/1srSCdZ



Read about the Houston Mission Control Center team that will be taking the helm of the Orion spacecraft for Exploration Flight Test-1 on page 4 of the JSC Roundup.

1.usa.gov/RvoMI2

Orion's parachutes tested in launch abort scenario

The team designing the parachute system for NASA's Orion spacecraft has tested for almost every parachute failure they could imagine. But on April 23, they tested how the system would perform if the failure wasn't in the parachutes.

Orion is the safest spacecraft ever built to carry humans, and its Launch Abort System can take a good deal of the credit for that distinction. In a life-threatening emergency on the launch pad or during the early stages of ascent, it will activate in milliseconds to propel the crew to safety. Once it has pulled the crew module away from danger, it's up to the parachutes to bring it down for a safe landing.

In a pad abort or a low altitude launch abort, Orion's three main parachutes would be called on to lower the crew module to the ground without the help of the two drogues that normally precede them. The parachute system won't have as long to do the job since the spacecraft will be at much lower altitude than for a nominal mission reentry, and with the vehicle going slower, they won't deploy as quickly. And on top of all of these factors, the crew module will be flying sideways when the parachutes deploy, instead of falling straight down as it does during reentry.

To simulate those conditions, a test version of Orion was dropped from a C-17 at 13,000 feet above the U.S. Army's Yuma Proving Ground, with the main parachutes deploying soon after leaving the plane, before the capsule had a chance to straighten out. All the elements worked together and the parachutes reached a fully open state, setting up a soft landing as expected. But the real value of the test will come with the data the engineers were able to gather from it.



In addition to the new test conditions, this was also the first time that the steel risers connecting the parachute lines to Orion were replaced with the textile risers that will be incorporated into future Orion spacecraft after Orion's first flight this year. The new risers are lighter and more flexible – two qualities that will come in particularly handy when Orion is ready to carry humans into space.

bit.ly/SEPFus

Orion's Launch Abort System's attitude control motor completes high thrust valve test

The attitude control motor (ACM) that steers Orion's Launch Abort System (LAS) and crew module away from the launch vehicle in the event of an emergency passed the motor's high thrust-9 (HT-9) valve test. The HT-9 test is a significant milestone for the motor, as it included a number of technical firsts, such as the valve operating at 100 percent thrust, and the highest maximum expected operating pressure for any ACM valve tested to date. It follows on a development campaign that included two full system demonstration tests and the Pad Abort-1 flight test.

Developed by ATK, the ACM consists of a solid-propellant gas generator, with eight proportional valves equally spaced around the circumference of the three-foot-diameter motor. In combination, the valves can exert up to 7,000 pounds



of steering force to the vehicle in any direction upon command from the crew module. As part of the LAS, the ACM responds to the guidance system as the LAS pulls Orion from hazards. The ACM then orients the capsule for parachute deployment. The quick-look data shows that all test objectives have been met and the design is validated.



Greg Hurst from KHOU-TV Channel 11 in Houston interviewed Orion's Mark Geyer and Julie Kramer-White (shown here), along with Astronaut Shane Kimbrough for a local television story.



Mark Geyer, Orion program manager was interviewed by National Fox News Correspondent Phil Keating on April 10 at Kennedy Space Center.



Lara Kearney, deputy manager, for the Orion crew and service module, spoke about Orion and engineering as a career path for students at the Clear Creek Independent School District career day at Clear Falls High School on April 3.



Darrel Williamson, Exploration Flight Test-1 vehicle manager for Lockheed Martin (center), speaks about Orion to faculty and staff at the Florida Institute of Technology on April 2.



Orion Program Manager Mark Geyer visited NASA's Glenn Research Center in Cleveland, Ohio, on April 24. Glenn Research Center provides critical support to the program including propulsion, manufacturing, vehicle integration and testing.



Lucy Kranz, program planning and control manager for Orion (fourth from left), was awarded the Rotary National Award for Space Achievement (RNASA) Stellar Award for her outstanding leadership and expertise in the programmatic control of large human spaceflight programs and personal dedication to NASA's mission.

Students' "rad" experiment design earns spot on Orion's first flight



All EDC Finalist Teams with representatives from NASA, the Lockheed Martin Orion industry team and National Institute of Aerospace

After a year-long competition, the Exploration Design Challenge (EDC) culminated with the announcement of the winning team at the USA Science & Engineering Festival in Washington, DC, which hosted more than 325,000 visitors April 25-27. NASA Administrator Charles Bolden and Lockheed Martin Chairman, President and CEO Marillyn Hewson jointly presented the prestigious honor to Team ARES from the Governors School for Science & Technology in Hampton, Virginia. The five-member high school team will be flown to Kennedy Space Center to watch their experiment launch into orbit on Exploration Flight Test-1.

The top five EDC finalist teams were invited to Washington, DC, to be recognized at the festival by NASA, Lockheed Martin and the National Institute of Aerospace for their outstanding work on this project. Orion industry team companies Aerojet/Rocketdyne, ASRC Federal, ATK, and United Technologies Aerospace Systems sponsored the travel expenses for the students: Team Aegis from Utah, Team ARES from Virginia, Team LORE from California, Team Titan from Illinois, and Team Erion from Kansas.

The Team ARES radiation shielding experiment incorporated a cubic prism design to block radiation from a dosimeter sensor as the Orion spacecraft passes through the Van Allen Belt, a dense radiation field that surrounds the Earth in a protective shell of electrically charged ions. The team's design received the highest radiation protection score during an online simulation of radiation exposure. They also demonstrated evidence of additional research outside of the material provided, and included additional information about the materials and estimated cost for their experiment.

The students will now work with the NASA and Lockheed Martin spacecraft integration team to build the flight hardware and have their experiment approved to fly in space.



Team ARES pictured with Bolden (left) and Hewson (right): Christopher Dobyns, Anna Montgomery, Sajan Sheth, Abid Rizvi, Danny McNamara and teacher sponsor Gregory Hajos

More than 130,000 students from 81 countries around the world have signed up to participate in the challenge, and 20,000 have completed it and earned the honor of flying their names on Orion. Students in grades K-12 still have until June 30 to complete the challenge.

Go to www.nasa.gov/education/edc to register and download a challenge activity.

The EDC announcement event aired on NASA-TV and may be seen at: bit.ly/1gcAHAY



All aboard! Senior leaders join the “I’m on Board” campaign

Senior leadership from NASA and Lockheed Martin signed up for Orion’s #ImOnBoard campaign this month to express their support for Exploration Flight Test-1 – NASA’s first step to deep space exploration.

Pictured are NASA Administrator Charles Bolden, Johnson Space Center Director Ellen Ochoa (right), Lockheed Martin Chairman, President and CEO Marilyn Hewson (below left), Orion Program Manager Mark Geyer, Glenn Research Center Director Jim Free and Deputy Director Greg Robinson (below right), Orion Program Astronaut Rex Walheim (far bottom left), NASA Associate Administrator for the Office of Communications David Weaver (far bottom right).





For the fifth year in a row, an Orion Small Business was chosen as Johnson Space Center's (JSC) Small Business Subcontractor of the Year. And this year, Houston Precision Fasteners (HPF) was recognized by JSC and agency-wide as NASA's 2013 Small Business Subcontractor of the Year. HPF custom designed and manufactured a unique bracket needed for the final assembly of the crew module. NASA's Small Business Industry Awards recognizes companies for their outstanding support to NASA.



The latest Exploration Systems Development video entitled "Acing the Test" showcases the latest progress and testing on the Orion, SLS and Ground Systems Development and Operations programs. The video is now online at: bit.ly/1ivSsei



NASA Orion Program Astronaut Rex Walheim spoke to young participants at the third annual USA Science and Engineering Festival held April 25-27 in Washington, DC. More than 325,000 people attended the event, which featured more than 3,000 hands-on activities, 150 performances and lectures, book signings and a career pavilion. Lockheed Martin and NASA were among the hundreds of exhibitors showcasing leading-edge technology and innovation. The festival helps to re-invigorate the interest of our nation's youth in science, technology, engineering and math (STEM) through compelling, educational and entertaining content.



Team ARES, winners of the Exploration Design Challenge, are helping to build Orion. Read more about the team at: on.fb.me/1oboML9

Coming up in May:

- Final Delta-IV Heavy booster shipment to KSC
- EFT-1 Joint Integration Simulation
- Crew Evaluation at NBL for Asteroid mission



Space Launch System

Highlights

April 2014



Avionics System for SLS Boosters Gets 'Boost' of Its Own on Path to Space

Eric Corder, right, avionics system manager at NASA's Marshall Space Flight Center, talks about the SLS booster avionics system at ATK's laboratory in Clearfield, Utah. The avionics system is responsible for igniting, steering and jettisoning the two five-segment solid rocket boosters for the SLS. The booster avionics system—including hardware, software and ground test systems—are being integrated into a complete forward skirt ring. The avionics testing, which will be completed this summer, will prove the system is ready to enter the qualification phase leading to SLS's first flight in 2017. For the full story, [click here](#). (ATK) ►

Artist concept of the SLS solid rocket boosters firing their separation motors and pushing away from the core stage, which continues toward space with the Orion spacecraft. (NASA/MSFC)



NASA Engineers Prepare Game Changing Cryotank for Testing



NASA and Boeing engineers inspect and prepare one of the largest composite rocket propellant tanks ever manufactured for testing. This advanced composite cryotank could benefit many of NASA's deep space exploration spacecraft, including SLS. For more information, [click here](#). (NASA/MSFC)

Signed, Sealed and Delivered

The adapter that will connect the Orion spacecraft to a Delta IV rocket for Orion's first flight test later this year is loaded onto a truck April 16 at NASA's Marshall Space Flight Center. The hardware—designed and built at the Marshall Center—was delivered later that night to United Launch Alliance (ULA) in Decatur, Ala. From there, it will travel by ship to Cape Canaveral, Fla. ULA is constructing the Delta IV rocket for Orion's first flight. (NASA/MSFC)



Spaceflight Partners: MT Aerospace

EDITOR'S NOTE: Every month, SLS Highlights turns the spotlight on one of the industry partners helping to create the largest rocket ever built for human space exploration. In this issue, we profile MT Aerospace of Germany.

MT Aerospace of Germany produces the dome gore panels for Boeing's core stage development of the Space Launch System. Gores are curved, pie-shaped, pre-formed aluminum alloy dome segments that are welded together to make the dome that caps the fuel tanks for the rocket. Complex, high-precision products have firmly established MT Aerospace as an innovative member of the global aerospace industry.

Founded in 1969, MT Aerospace has grown to be a trusted partner in the space industry around the world.



▲ Boeing weld engineer Guillermo Ladut and fabrication specialist Todd Duhon calibrate settings for the next dome weld test at NASA's Michoud Assembly Facility. Each gore panel is placed on the tool to be welded to 11 other identical pieces to form the dome that will cap an SLS fuel tank. (Boeing)

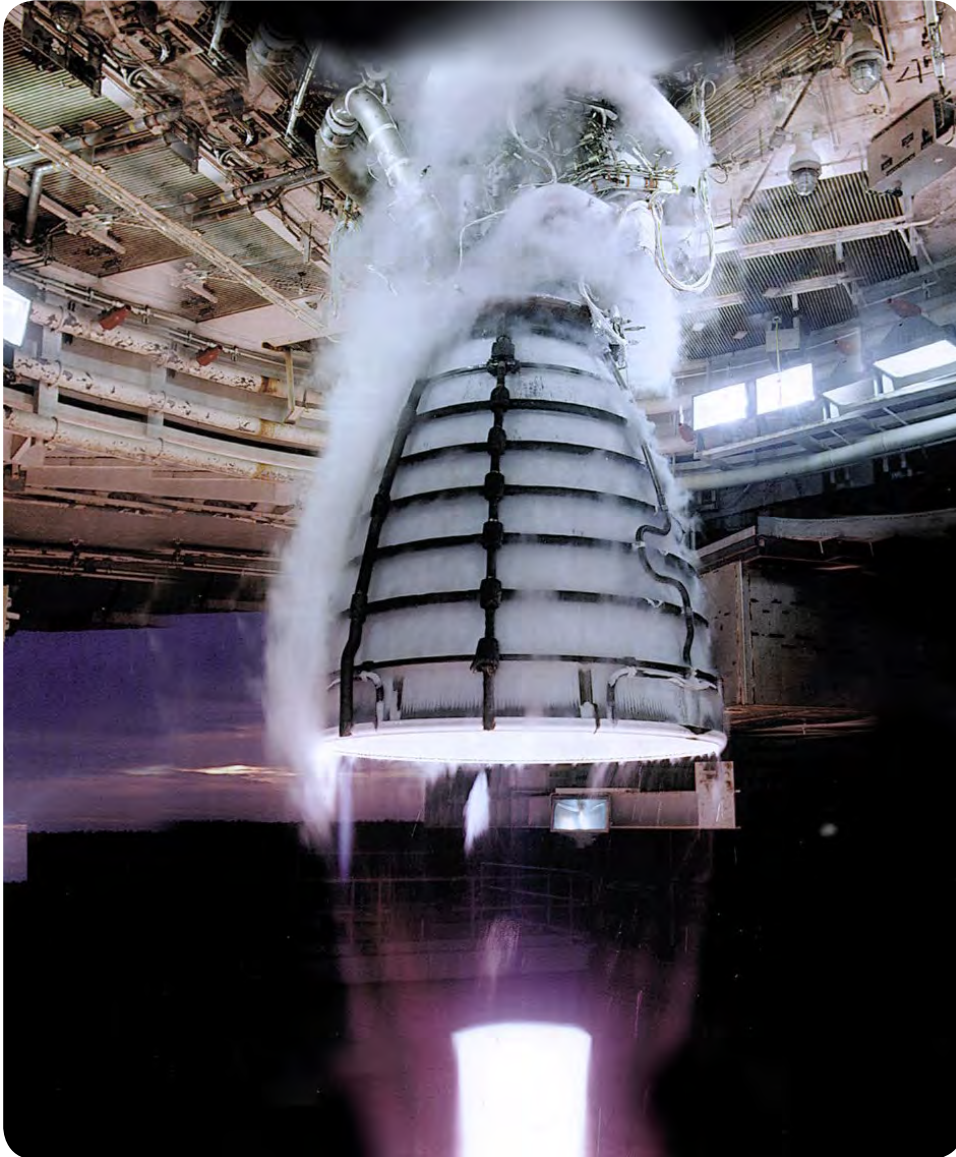
◀ Gore weld panels from MT Aerospace are placed for the next friction stir weld test at Michoud Assembly Facility. (Boeing)

Space Launch System, Cryotank Project Teams Win Stellar Awards

Two teams from NASA's Marshall Space Flight Center recently were honored by the Rotary National Award for Space Achievement Foundation with Stellar Awards—recognizing accomplishments that hold the greatest promise for furthering future activities in space. Teams from the SLS Program and Composite Cryotank Technology Demonstration Project were among the 10 winners selected from 164 nominees. Accepting the awards are, fifth from left, Justin Jackson, project engineer for the NASA Composite Cryotank Technology Demonstration Project, and SLS Program Manager Todd May, fifth from right. NASA astronauts Karen Nyberg and Douglas Hurley presented the awards April 11 at the annual foundation gala event in Houston. For the full story, see the [April 30 issue](#) of the Marshall Star. (RNASA Foundation)



NASA Gears Up for Next Set of Engine Tests for SLS



The RS-25 engine that will power SLS off the launch pad and on journeys to an asteroid and Mars is getting ready for the test stand at NASA's Stennis Space Center now that J-2X has finished testing. Formerly known as the space shuttle main engine, the RS-25 accumulated over 1 million seconds—or almost 280 hours—of hot fire experience during 135 missions and numerous related engine tests like the one pictured here. A number of J-2X test objectives offer benefits to the upcoming battery of RS-25 tests, including defining the performance, control and data characteristics of the test stand, and new processes used to record and interpret engine performance data. To watch the last J-2X engine test, [click here](#). (Aerojet Rocketdyne)

I am building SLS
Mike Beckstrand
Stage Controls Program Manager



To find out more about the people who are building SLS, [click here](#).

SLS On the Road...



The SLS and Orion spacecraft inflatables on display April 3 at NASA Alabama Aerospace Day in Montgomery. (NASA/MSFC)



SLS team member Kirk Pierce speaks with students April 30 at the Philadelphia Academy Charter School. (NASA/MSFC)



SLS team member Trey Cate talks to visitors April 30 at the Fumo Family Library in Philadelphia about the agency's new rocket. While in the "City of Brotherly Love," the SLS team talked with several schools, attended a Philadelphia Phillies game for "Science Night at the Ballpark" and staffed a NASA exhibit at the Science Carnival on the Parkway. (NASA/MSFC)



NASA Administrator Charles Bolden, left, talks about the path to Mars using NASA's new rocket with SLS team members Shannon Raleigh, second from left, and Twila Schneider on April 25 at the USA Science & Engineering Festival in Washington. (NASA/MSFC)

For more SLS news, updates and resources, visit www.nasa.gov/sls

Follow SLS on:



SLS on Deck:

- Full-assembly Scale Model Acoustic Testing continues
- Construction begins on new SLS test stands at Marshall
- Booster forward skirt structural loads testing



PROGRAM HIGHLIGHTS • APRIL 2014

At NASA's Kennedy Space Center in Florida, the Ground Systems Development and Operations (GSDO) Program Office is leading the center's transformation from a historically government-only launch complex to a spaceport bustling with activity involving government and commercial vehicles alike. GSDO is tasked with developing and using the complex equipment required to safely handle a variety of rockets and spacecraft during assembly, transport and launch. For more information about GSDO accomplishments happening around the center, visit <http://go.nasa.gov/groundsystems>.

Firing Room 4 Will Feature Multi-User Concept Layout

A metamorphosis is taking place inside Firing Room 4 (FR4) in the Launch Control Center at NASA's Kennedy Space Center in Florida. The Ground Systems Development and Operations (GSDO) Program is overseeing the work to create a new firing room as part of NASA's effort to transform Kennedy into a multi-user spaceport.

Unlike previous work at Kennedy focusing on a single kind of launch system, such as the Saturn V rocket or space shuttle, engineers are preparing the spaceport's infrastructure to support several different spacecraft and rockets in development for human exploration.

The new concept for FR4 will feature four separate firing room areas to serve NASA and potential commercial or private users' needs. Eight-foot-high walls will divide the rooms, with each room measuring 30 by 32 feet. Each room will have a door and large window with privacy blinds. Interconnecting doors will allow users access to more space if needed.

In November 2013, work began to reconfigure the room that supported shuttle launches for its future purpose. All of the main floor launch consoles and some upper-level consoles were removed, along with all of the shuttle-era cables and wiring beneath the floor. Completely new wiring and subflooring has been installed. High above, the ceiling tiles have been removed, exposing conduits and wiring.

"The new construction shows life and we're moving forward," said Steve Cox, the GSDO element operations manager for the Launch Control Center.

Construction workers are busy installing the supports so that the walls can be added. The room has been measured off and steel beams dot the floor in an orderly fashion.

"We have a plan. We have a purpose and a focus," Cox said. "We're providing the tools that will allow others to do their job more efficiently."

For the complete story, visit <http://go.nasa.gov/1mIZOZW>



Construction workers have installed the framing and some of the inner walls inside Firing Room 4 in the Launch Control Center.

New Coatings Tested for Kennedy Facilities and Structures

The Technology Evaluation for Environmental Risk Mitigation (TEERM) Principal Center in NASA's Environmental Management Division has partnered with the Ground Systems Development and Operations (GSDO) Program at Kennedy Space Center to investigate and test a variety of protective coatings that would serve as a barrier between the center's carbon steel on facilities, launch structures, and ground support equipment and the harsh corrosive environment.

According to many published studies of marine environments throughout the country and other parts of the world, Kennedy has one of the highest corrosion rates.

"The incorporation of environmentally responsible materials is a key component of the GSDO Program's goal to make Kennedy a sustainable spaceport of the future," said Joni Richards, TEERM Program manager. "TEERM is actively helping to address one of the biggest concerns, corrosion, by qualifying greener alternatives to protect steel structures and ground support equipment."

Currently, many of Kennedy's structures are protected with coatings that work well preserving steel but contain hazardous chemicals that could harm the environment. New spray-on coating systems are being investigated as GSDO prepares the center to process and launch the next generation of rockets and spacecraft for NASA and commercial missions.

For Stage 1 testing, 10 coatings were selected based on requirements such as ease of application, what kind of surface preparation is needed and surface appearance under magnification. The samples were applied to panels at the Beachside Atmospheric Test Facility at the Corrosion Technology Lab. They were exposed to the marine atmosphere for 18 months.



A protective coating is sprayed on a sample panel for testing at the Beachside Atmospheric Test Facility.

At the end of the first round of tests earlier this year, three of the coating samples showed acceptable performance. The next step will be to expose these samples to liquid oxygen and hypergols to test their compatibility.

"GSDO is dedicated to performing its mission using the most sustainable and cost-effective technologies," said Bill Simmonds, GSDO project manager for Environment and Infrastructure.

For the complete story, visit <http://go.nasa.gov/1mm06jA>



NASA Kennedy Space Center's Beachside Atmospheric Test Facility at the Corrosion Technology Lab currently is being used to test a variety of protective coatings for the center's carbon steel structures.



Inside the Vehicle Assembly Building at Kennedy Space Center, ground support technicians monitored the progress as an overhead crane lifted a sprocket shaft assembly away from the crawler-transporter 2 on April 17. A section of the treads were removed to allow access to the sprocket assemblies.



Modifications continued on the Mobile Launcher (ML) on April 22 at the Mobile Launcher Park Site at Kennedy Space Center. Construction workers on lifts prepared to cut and weld sections of the metal walls on the exterior of the ML.



Modifications continued on the Multi-Payload Processing Facility at Kennedy Space Center. The high bay entrance was recently enlarged and a new door installed. Construction workers are installing new siding around the entrance. The extensive upgrades and modernizations will support processing of Orion spacecraft for NASA's exploration missions. The 19,647-square-foot building, originally constructed in 1995, primarily will be used for Orion hypergolic fueling, ammonia servicing and high-pressure gas servicing and checkout before being transported to the Vehicle Assembly Building for integration with the Space Launch System.

Employee Spotlight - Russell Stoewe

Russell Stoewe is the crawler-transporter (CT) project manager in the Engineering Directorate at Kennedy Space Center. In this position, Stoewe leads the requirements development and verification/validation processes on the crawler upgrades projects. Upgrades and modifications to CT2 are being done so that it can carry the increased weight of NASA's Space Launch System and Orion spacecraft.

Stoewe began his career at Kennedy 13 years ago and worked on the Space Shuttle Program as an operations engineer and project manager.

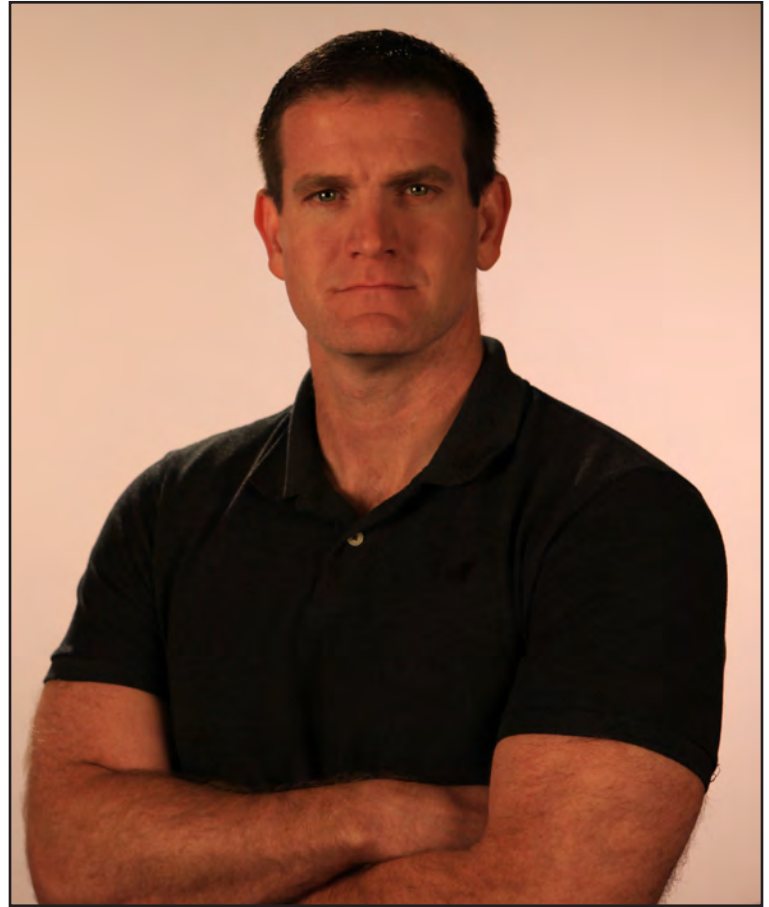
"One of my favorite memories working at Kennedy was the last space shuttle rollout, STS-135, in 2011," said Stoewe. "The amount of support from the community that watched from the turn basin was amazing, and having my family see the operation was a perfect way to close out the program."

Stoewe said he appreciates the opportunity to work for NASA at the most prestigious space agency in the world.

"It's a good feeling knowing that I am helping to provide a vital service to mankind's exploration of the cosmos," Stoewe said.

His first car was a blue 1988 Honda Accord. After graduation from college, his first purchase was a grey 2001 Mustang.

Stoewe lives in Oviedo. His hobbies include baseball and running marathons. He also is a published author. His first book, "Number 181," was published in 2012,



and the second, "Tin Man," was published in 2013.

His family includes parents Russell and Patricia, sister Michelle, and niece and nephew Elyse and Evan.



On April 17, ground support technicians used a special work stand to guide an ice-covered roller bearing shaft for insertion on the crawler-transporter 2 inside the Vehicle Assembly Building at Kennedy Space Center.

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EXPLORATION SYSTEMS DEVELOPMENT



Construction continues in Firing Room 4 in the Launch Control Center at NASA's Kennedy Space Center in Florida. GSDO is overseeing efforts to create a new firing room based on a multi-user concept that will support NASA and commercial launch needs. (Image Credit: NASA/Ben Smegelsky)