National Aeronautics and
Space Administration

ORION

AUGUST 2016

ORION GETS FIRED UP!

ORION'S MONTHLY HIGHLIGHTS

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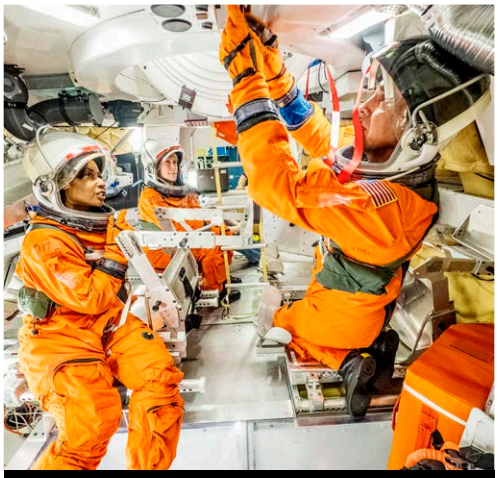

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Left to right: Howard Hu (NASA), Robert Decoursey (NASA), Cheryl Rehm (Aerojet Rocketdyne), Roger McNamara (Lockheed Martin), Jim Paulsen (Aerojet Rocketdyne), Sasha Ellis (NASA) and Don Mahr (Aerojet Rocketdyne) pose in front of the Orion Jettison Motor test stand following the test firing.

AEROJET ROCKETDYNE COMPLETES SUCCESSFUL JETTISON MOTOR TEST

You often don't think that something the size of a college dorm refrigerator is capable of lifting two schools buses off the ground, but that is exactly the case with Orion's jettison motor. At the end of August, representatives from NASA, Lockheed Martin, Aerojet Rocketdyne and local congressional staff including Representative Bera (D-CA), Rep. Matsui (D-CA) and Rep. McClintock (R-CA) gathered to watch the third development jettison motor for Orion generate 45,000 pounds of thrust during a 1.5 second test firing in Sacramento, California.

One and half seconds may seem like an extremely short time, but that is all the time required to separate Orion's launch abort system (LAS) from the crew module. The LAS consists of three solid rocket motors: the abort motor that pulls the crew module away from the launch vehicle; the attitude control motor that is used to steer the crew module following an abort; and the jettison motor, which separates the launch abort system from the crew module.

This most recent test of the jettison motor provided Aerojet Rocketdyne and Lockheed Martin key data, including pressure, temperature, thrust, acceleration and strain measurements to ensure their readiness to begin manufacturing the qualification and flight production motors for Exploration Mission-1 (EM-1).

Senior leadership from NASA, Lockheed Martin and Aerojet Rocketdyne welcome Congressman Ami Bera (at right) to watch the jettison motor test.

To watch video of the test, visit: http://bit.ly/OrionJettisonTestVideo

Read how Orion's Launch Abort System Motor Gets Fired-Up About the Journey to Mars at: http://bit.ly/OrionFiredUp

Astronauts Stephanie Wilson, Karen Nyberg and Rick Mastracchio check out Orion's docking hatch.

HATCHING NEW IDEAS FOR SPACECRAFT DESIGN

Engineers and astronauts conducted testing in a representative model of the Orion spacecraft at NASA's Johnson Space Center to gather the crew's feedback on the design of the docking hatch and on post-landing equipment operations. The testing, shown here with astronauts Stephanie Wilson, Karen Nyberg and Rick Mastracchio (L to R), was done to evaluate the equipment used during egress to ensure that a fully suited crew member carrying survival equipment can get out of the spacecraft through the docking hatch if necessary.

While the crew will primarily use the side hatch for entry and exit on Earth and the docking hatch to travel between Orion and a habitation module on long-duration deep space missions, the crew will need to be able to exit out of the docking hatch if wave heights in the Pacific Ocean upon splashdown are too high. The work is being done to help ensure all elements of Orion's design are safe and effective for the crew to use on future missions on the journey to Mars.

Orion Backstage Video: **http://bit.ly/OrionHatchBackstage**

Astronaut Anne McClain and Orion engineers and astronauts evaluate radiation sheltering procedures inside the Orion mockup at Johnson Space Center in Houston.

ORION CREW LEARN HOW TO SHELTER IN SPACE

Radiation shelter evaluations were conducted in a full-scale Orion mockup at NASA's Johnson Space Center in August to determine the amount of time astronauts would need to complete crew cabin reconfiguration to create a safe haven from deep-space radiation in the event of a solar particle event.

The Orion crew will take shelter in the central stowage bays, which can accommodate four crew members. The stowage components double as radiation shielding blocks when they are strategically repositioned at specific locations around the crew cabin to optimize protection. The cabin reconfiguration is an operations intense process that requires about 30 to 60 minutes to complete.

Spaceflight veteran Dr. Don Pettit participated in the exercises to provide real-time feedback from an astronaut's perspective. The radiation protection team assessed the desired mass density and material properties best suited for radiation shielding to meet requirements.

As part of an ongoing international collaboration between Lockheed Martin and StemRad Israel, the radiation protection design team is working on the development of a personal radiation shield that could provide radiation protection comparable to that inside the Orion shelter but with improved mobility of crew during solar particle events, which can occur anytime and on very short notice.

Astronaut radiation protection is essential to human exploration of deep space because astronauts will be traveling outside the protection of the Earth's magnetosphere and exposed significantly harsher radiation beyond Earth's orbit. Without adequate protection, the crew could experience detrimental health effects including increased risk for certain cancers.

Orion is NASA's first stand-alone spacecraft to implement radiation protection engineering as an integral part of the design process from the very early development stages of the preliminary design review.

Read the facts: http://bit.ly/OrionRadiationFS

ORION SPLASHDOWN TESTS KEEP ASTRONAUTS SAFE

Ellen Ochoa, director, NASA Johnson Space Center speaking with attendees of a NASA Social at the Orion splashdown test taking place Aug. 25 at NASA's Langley Research Center.

Onlookers gathered near the Hydro Impact Basin at NASA's Langley Research Center in Hampton, Virginia, applauded and cheered as they witnessed the simulated water landing of the Orion spacecraft, through the use of a 7.2-ton mockup covered with sensors capable of detecting forces that the structure and its astronaut crew would experience.

The drop was the ninth in a series of 10 tests taking place at Langley's Landing and Impact Research Facility. It was designed to simulate one of the Orion spacecraft's most stressful landing scenarios, a case where one of the capsule's three main parachutes fails to deploy. That would cause Orion to approach its planned water landing faster than normal and at an undesirable angle.

Under ideal conditions, the Orion capsule would slice into the water of the Pacific Ocean traveling about 17 miles per hour. Thursday's test had it hitting the pool at about 20 mph, and in a lateral orientation. Instead of being pushed down into their seats, astronauts in this scenario would splashdown to the side.

The tests at Langley — along with many others across the agency — are leading up to the first integrated flight of the Space Launch System (SLS) and Orion known as Exploration Mission-1. There will be no crew on EM-1, but it will prepare the way for future missions with astronauts as NASA pushes ahead on its journey to Mars.

To read the full article, visit: http://bit.ly/OrionSplashdown

A COOL TEST FOR CREW SAFETY

The third and final Launch Abort System (LAS) abort motor igniter qualification static test firing was successfully performed at the Orbital ATK test facility in Promontory, Utah, the morning of August 9. This igniter was conditioned by cold temperature cycles (25-35 degrees Fahrenheit) and vibration testing prior to the cold condition static test.

Conducting igniter static tests is part of the design, development, test and evaluation program. Igniters are tested to validate engineering models, and verify predicted performance after subjection to the expected extreme pre-operating and flight conditions. The three igniter tests consisted of nominal, hot (95-105 degrees Fahrenheit) and cold temperature extremes to qualify the igniter prior to operational production.

This test is a significant milestone for Orion and an important step forward on the path to full qualification of the abort motor for the LAS. A full-scale abort motor static test firing is planned for mid-2017.

HOT SHOT DELIVERY!

The heat shield that will protect the Orion crew module during reentry after the spacecraft's first uncrewed flight atop NASA's Space Launch System rocket in 2018 arrived at the agency's Kennedy Space Center in Florida on Aug. 25. The heat shield arrived aboard NASA's Super Guppy aircraft at Kennedy's Shuttle Landing Facility, and was offloaded and transported to the Neil Armstrong Operations and Checkout Building high bay.

The heat shield was designed and manufactured by Lockheed Martin in the company's facility near Denver. Orion's heat shield will help it endure the approximately 5,000 degrees F it will experience upon reentry. The heat shield measures 16.5 feet in diameter and is the world's largest structure of its kind.

MULTI-PAYLOAD PROCESSING FACILITY PROVIDES 'GAS STATION' FOR ORION

The first stop when loading up the family car to go on a long trip usually is the gas station. Before NASA's Orion spacecraft launches on deep-space missions, an important step to "fill 'er up" will include a visit to the Multi-Payload Processing Facility (MPPF) at the agency's Kennedy Space Center in Florida.

At the MPPF, Orion will receive its flight load of propellant, high pressure gases and coolant in a building where recently completed modifications now are being tested.

The Orion crew module for EM-1 now is being assembled inside the Neil Armstrong Operations and Checkout Building at Kennedy. The next step will be to mate the spacecraft to its service module. The combination then will move to the MPPF.

Once commodity loading and tests are completed in the MPPF, the next stop will be the Launch Abort System Facility where the Orion spacecraft will be fitted with its launch abort tower and fairing assembly. From there, it's on to the Vehicle Assembly Building for mating to the SLS rocket prior to rollout to Launch Complex 39B.

Read the full article at: http://bit.ly/OrionGasStation

Left-to-right: Bob Kamm (Space Coast Transportation Planning Organization); Percy Luney (Space Florida); Joe Mayer (Lockheed Martin), John Murray (Port Canaveral), Todd Pokrywa (The Viera Company); and Lynda Weatherman (Economic Development Commission of Florida's Space Coast). Photo Credit: Jim Carchidi – Orlando Business Journal

LOCKHEED MARTIN TALKS ORION/SPACE EXPLORATION IN ORLANDO

Joe Mayer with Lockheed Martin Government Relations in Florida, discussed assembly of the Orion Exploration Mission-1 spacecraft and NASA's Journey to Mars during an Orlando Business Journal forum on "Business in Brevard" on Aug. 25. More than 200 attendees representing a broad cross section of businesses throughout the Space Coast area attended the lunch forum session that covered a range of topics important to Brevard county.

NASA's Lara Kearney and Astronaut Rick Mastracchio (middle) and Lockheed Martin's Chris Lacoste, Mark McCloskey and Josh Fineout in the Orion manufacturing area at NASA' Michoud Assembly Facility, New Orleans.

NASA AND INDUSTRY TEAM PARTNERS SHOWCASE JOURNEY TO MARS PROGRESS

NASA hosted events on August 18 to give social media users, news reporters and VIP guests a behind-the-scenes look at advancements in science, technology and human spaceflight operations to prepare for deep space exploration of our solar system on the agency's journey to Mars.

Attendees got a close-up look at some of the world's largest welding and manufacturing machines at NASA's Michoud Assembly Facility in Louisiana used on the Space Launch System rocket and Orion.

The Orion spacecraft manufacturing team at Michoud touches every structural piece of the Orion spacecraft from tip to tail for friction-stir welding operations, crew module assembly and structural integrity testing.

Following the event at Michoud, reporters traveled to NASA's Stennis Space Center in Mississippi where they

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got to witness a full duration test firing of one of the RS-25 engines that will help propel NASA's new rocket far beyond Earth for space exploration missions beyond the moon. While at Stennis, attendees toured the Aerojet Rocketdyne rocket engine facilities and the B-2 test stand that is being renovated for SLS core stage testing.

NASA and industry team experts talked with media about technologies needed to explore the Red Planet, including SLS, Orion and ground systems operations, as well as habitat and lander development, landing site selection, propulsion, advanced manufacturing and robotic exploration.

To read the full article, visit: http://bit.ly/MichoudSocial

NASA PREPARES FOR ORION EUROPEAN SERVICE MODULE PROPULSION QUALIFICATION TESTING

Engineers are preparing for tests to qualify the propulsion subsystem, including the main engine, for Orion's European-built service module that will propel the spacecraft during different phases of flight in deep space. They will test engineering units of the spacecraft elements that will fly on Orion's first test flight with NASA's Space Launch System rocket in late 2018, moving the agency another step forward on its journey to Mars.

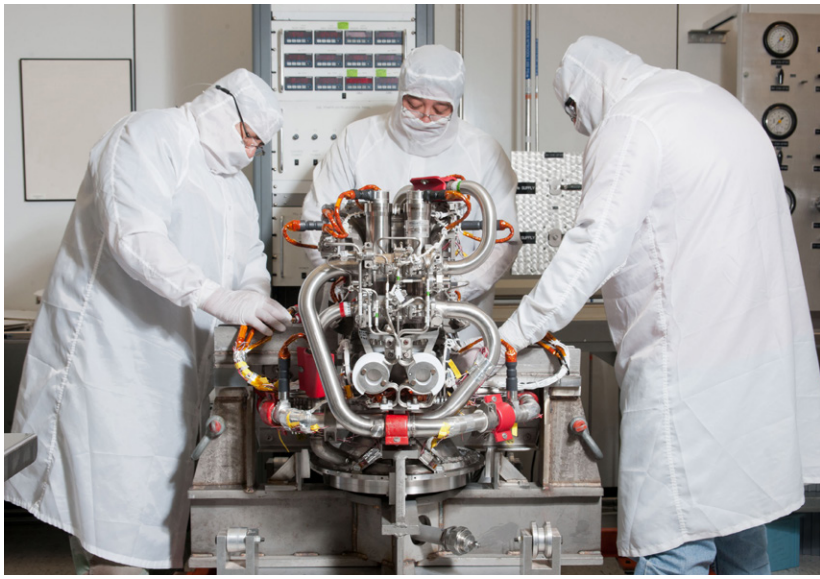
NASA is scheduled to test a propulsion qualification module including flight-like test units of the engine, propellant systems, and propulsion control units at the agency's White Sands Test Facility (WSTF) in New Mexico beginning in spring 2017.

Orion's service module main engine is a modified Orbital Maneuvering System (OMS) engine initially used on the space shuttle. NASA is repurposing the OMS engines for use in the European service module.

The Propulsion qualification module that will be used for testing is currently being assembled by ESA contractor, Airbus Defence and Space. It is scheduled for delivery to WSTF later this year. It consists of several helium tanks, propellant tanks, thrusters and flight-representative equipment such as piping, electronics, pressure control assemblies, a pressure regulation unit and propellant isolation equipment.

Data from the testing at WSTF will support verification of the proper operation of the service module propulsion system.

The propulsion team at White Sands Test Facility in Las Cruces, New Mexico, will test the engine for Orion's European Service Module.



While the main engine and test facilities are prepared for the spring hot-fire, the main engine for flight has been refurbished and acceptance tested at WSTF, and was shipped to NASA's Johnson Space Center in Houston for vibration testing. The vibration testing is helping to ensure the engine can withstand the loads induced by launch on the SLS rocket. Following testing at Johnson, the flight engine will be supplied to ESA to integrate into the Orion European service module for flight.

The Orion crew module for Exploration Mission-1 is transferred into the clean room inside the Neil Armstrong Operations and Checkout Building at Kennedy Space Center for installation of the spacecraft's critical systems, including propellant lines.

PROPELLENT TUBE WELDING BEGINS ON ORION EM-1 SPACECRAFT

Assembly of the Orion crew module for the first uncrewed flight test atop NASA's Space Launch System reached a significant milestone this month in the Neil Armstrong Operations and Checkout Building high bay at the agency's Kennedy Space Center in Florida. Lockheed Martin, manufacturer of Orion, and its subcontractor engineers, technicians and X-ray specialists completed the first propellant system tube welds on the exterior of the Orion pressure vessel.

Orion's propulsion lines are comprised of multiple metal tubes of varying lengths that are welded together around the vehicle. With the first tubes in place, X-ray specialists performed inspections of the welds for any imperfections. This process will be repeated as each of the remaining tube assemblies are completed along the exterior of the crew module in the clean room.

The propellant lines will provide hydrazine to the spacecraft thrusters during missions into deep space. The propellant lines complete a continuous connection from the propellant tanks in the aft bay of the crew module to the spacecraft's thrusters, which are part of the system that helps to steer the capsule during the mission.

Orion was moved from the birdcage assembly fixture and secured in the clean room for the first time in late July. The first propellant system weld was completed in the clean room. The spacecraft's critical systems, including the Environmental Control and Life Support System and propellant lines, will be completed in this room.

Read the full story at: http://bit.ly/OrionPropWelding

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SEPTEMBER

Final Splashdown Test at LaRC

Journey to Mars Suppliers Visit KSC

Orion Participates in Fleet Week in San Diego

International Astronautical Congress Highlights