National Aeronautics and Space Administration

NASA

ORION

SEPTEMBER 2015

EXPLORATION MISSION-1 CREW MODULE COMES TOGETHER

PRESSURE VESSEL WELDING PROGRESSES AT MICHOUD FACILITY

Lockheed Martin engineers at NASA's Michoud Assembly Facility in New Orleans, began welding the Orion spacecraft pressure vessel for Exploration Mission-1 on Sept. 5.

The pressure vessel is the primary structure of Orion's crew module and is made of seven large aluminum pieces that must be welded together in detailed fashion. The first weld connected the tunnel to the forward bulkhead, which is at the top of the spacecraft and houses many of Orion's critical systems, such as the parachutes that deploy during reentry. Orion's tunnel, with a docking hatch, will allow crews to move between the crew module and other spacecraft.

This is the third Orion pressure vessel built, following the ground test vessel and the vessel for Exploration Flight Test-1 (EFT-1). Through collaborations across design and manufacturing, the team reduced the number of welds from 33 on the first pressure vessel to seven on the current one, saving about 700 pounds of mass.

During the coming months, as other pieces of Orion's primary structure arrive at Michoud from machine houses across the country, engineers will inspect and evaluate them to ensure they meet precise design requirements before welding. Once complete, the structure will be shipped to NASA's Kennedy Space Center in Florida where it will be assembled with the other elements of the spacecraft, integrated with the Space Launch System (SLS) and processed before launch.

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NASA COMPLETES KEY MILESTONE FOR ORION SPACECRAFT IN SUPPORT OF JOURNEY TO MARS

NASA's mission to send astronauts to deep space destinations has taken another important step forward with the completion of a critical milestone for the Orion spacecraft currently in production.

Agency officials have completed a rigorous technical and programmatic review, confirming continued support of the program and establishing NASA's commitment to the program's technical, cost, and schedule baseline. This is the first time NASA has reached this level of progress for a spacecraft designed to take humans into deep space beyond the moon, including to an asteroid placed in lunar orbit and on the journey to Mars.

The decision commits NASA to a development cost baseline of $6.77 billion from October 2015 through the first crewed mission, Exploration Mission-2, and a commitment to be ready for a launch with astronauts no later than April 2023. The commitment is consistent with funding levels in the president's budget request. Conservative cost and schedule commitments align the Orion Program with program management best practices that account for potential technical risks and budgetary uncertainty beyond the program's control.

Although Orion's readiness date for Exploration Mission-1 was not formally part of this milestone commitment, the Orion team continues to work toward an uncrewed mission in fall 2018.

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BUILDING BLOCKS OF THERMAL PROTECTION DESIGN

When it comes to building a spacecraft fit for a journey to Mars, improvements happen brick by brick and block by block. Orion Program leaders have decided to begin building Orion's heat shield in blocks rather than as a monolithic structure, a move that signals the insights gained as a result of testing the design in space.

The heat shield is one of the most critical elements of Orion and protects it and the future astronauts inside from searing temperatures experienced during reentry through Earth's atmosphere when they return home. For Exploration Mission (EM)-1, the top layer of Orion's heat shield that is primarily responsible for helping the crew module endure reentry heat will be composed of approximately 180 blocks that can be built in stages, easing the labor-intensive manufacturing process.

Orion's flight test last December provided an opportunity to develop confidence in the overall system and provide insight that can't be gained from models in the laboratory. The heat shield experienced temperatures of about 4,000 degrees Fahrenheit and speeds approximately 80 percent of what it will endure when it comes back from missions near the moon, all while keeping the temperature inside the crew module in the mid-70s. Post-flight examinations of the heat shield confirmed it performed well within expected tolerances.

Through lessons and data obtained from building and flying the heat shield, the team was able to make a design update for the Avcoat block design that will meet the EM-1 strength requirements. It is also expected to provide a cost savings and shorten the current heat shield manufacturing timeline by about two months.

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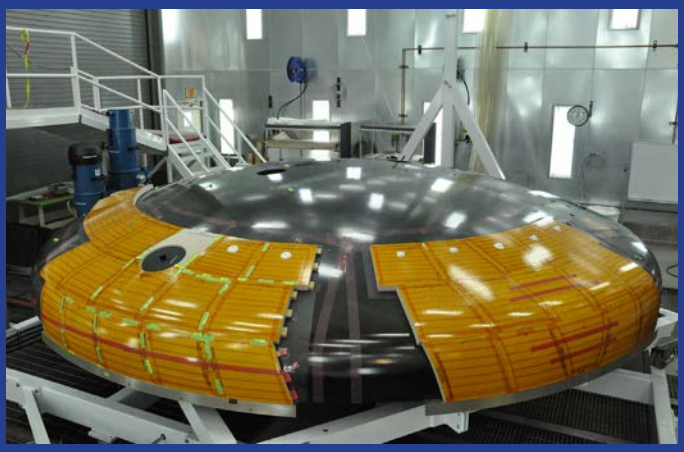


A manufacturing development unit of Orion's heat shield is being built at Lockheed Martin's facility in Denver. Engineers are using the unit to verify the new heat shield manufacturing process before it is used on flight hardware.

A POWERFUL START FOR ORION MISSION TESTING

On Sept. 24, the Orion Program officially powered on the Lockheed Martin Orion Test Lab in Littleton, Colorado (shown here during its grand opening in July). This significant milestone establishes Exploration Mission-1 test capabilities with flight-like hardware, avionics and software.

The lab will serve as the proving ground for the vehicle's test procedures, perform the majority of verification testing and ultimately perform full flight simulations of upcoming mission challenges. The lab will also provide real-time trouble shooting to solve any anomalies that could threaten a launch opportunity or mission objective.

ORION'S PARACHUTE TEAM ADVANCES TO PRODUCTION

The Capsule Parachute Assembly System team (shown above) completed their Critical Design Review (CDR) on Sept. 15-16 for the Exploration Mission design.

The objectives of the CDR were to finalize the technical design for qualification and flight hardware, and to provide objective evidence that the design is ready for production, including analysis and testing results that demonstrate the design will meet its requirements. It will also provide the final verification and validation activities to be used for qualification and acceptance. The CDR will be finalized following the next drop test in Jan. 2016.

AIRBUS DS DELIVERS FIRST PROPULSION TANKS FOR ORION SPACECRAFT'S EUROPEAN SERVICE MODULE

Airbus Defense and Space completed the first hardware for the European Service Module (ESM) for the Exploration Mission-1 Orion spacecraft. In contrast to the ESM flight hardware , which will be built at the company's Bremen site in Germany, the European structural test article (eSTA), which is being delivered to NASA for testing, is being assembled by Thales Alenia Space in Turin, Italy, where all four of the propulsion system tanks were delivered at the end of September.

The tanks are currently being supplied without internal components since eSTA testing requires only the tank shell filled with test fluid. The primary goal of the initial tests is to verify that the structural components can withstand the enormous loads, especially during liftoff. The ESM will provide propulsion, power and thermal control for Orion, as well as supplying the crew with water and oxygen during the mission. It will therefore accompany the Orion crew module through virtually every stage of the flight, separating from the spacecraft just before Orion re-enters Earth's atmosphere.

While the eSTA undergoes assembly in Italy followed by testing at NASA Glenn Research Center's Plum Brook Station near Sandusky, Ohio, EM-1 service module work in Bremen continues moving forward. The next step is to build the engineering model that will be assembled and tested at Airbus DS. This model will be used to test the propellant management device installed in the tanks to ensure a continuous, bubble-free flow of propellant to the spacecraft's motors.

A total of some 30 people throughout Germany are currently working on the engineering, design and production of the tanks in Bremen and Ottobrunn. The tanks are part of the propulsion subsystem that is being developed at the Bremen and Lampoldshausen sites.

The actual flight tanks for the ESM, which will be used for the first time when the uncrewed Exploration Mission-1 launches, are due to be completed in Bremen by mid-2016.

AEROJET ROCKETDYNE ORION SUBSYSTEMS ON TRACK FOR 2018 LAUNCH

The jettison motor and crew module reaction control system, which Aerojet Rocketdyne is building under contract to Lockheed Martin for NASA's Orion spacecraft, are on track for a 2018 launch after completing Critical Design Review (CDR). These two major subsystems are critical for ensuring astronaut safety and mission success.

The jettison motor is a solid rocket motor that separates the launch abort system from the Orion spacecraft about five seconds after fairing separation, allowing the crew to continue safely on their way into deep space. In addition to its normal operations, the jettison motor serves a double duty if an anomaly occurs. Designed to assist crew escape, the jettison motor is one of three solid rocket motors on the launch abort system that will rapidly pull the capsule away from the stack in the event of an emergency.

Orion's crew module reaction control system (CM RCS) is equally important to crew safety. The CM RCS provides the only course control authority after the separation from the service module. It ensures the heat shield is properly oriented, the crew module is stable under the parachutes and that the vehicle is in the correct orientation for splashdown. The reaction control system team started a redesign in October 2013 based on modeling and simulation demonstrations theorizing different operational environments for the system, which the Exploration Flight Test-1 (EFT-1) mission in December 2014 confirmed.

The CM RCS that Aerojet Rocketdyne is now manufacturing for delivery to Lockheed Martin next year is significantly enhanced from the system flown on EFT-1. Design changes include: increasing the structural capability of engines and the support structure; increased engine nozzle temperature capability to withstand more severe aero-thermal environments during reentry of the crew module into Earth's atmosphere; and reducing overall mass of the system. The successful CDR also verified the new design and confirmed the use of cutting-edge additive manufacturing technology in the fabrication of engine components.

With the successful CDR completion, Aerojet Rocketdyne is now able to begin manufacturing hardware for installation into Orion for Exploration Mission-1, which is slated for launch readiness in 2018 and will be the first flight to the proving ground of deep space.

Below: The Reaction Control System team at their Redmond, Washington location.

EM-1 IN THE MAKING

NASA Deputy Administrator Dava J. Newman visited Michoud Assembly Facility in New Orleans in September to see the progress on the Orion crew module that will fly on Exploration Mission-1.

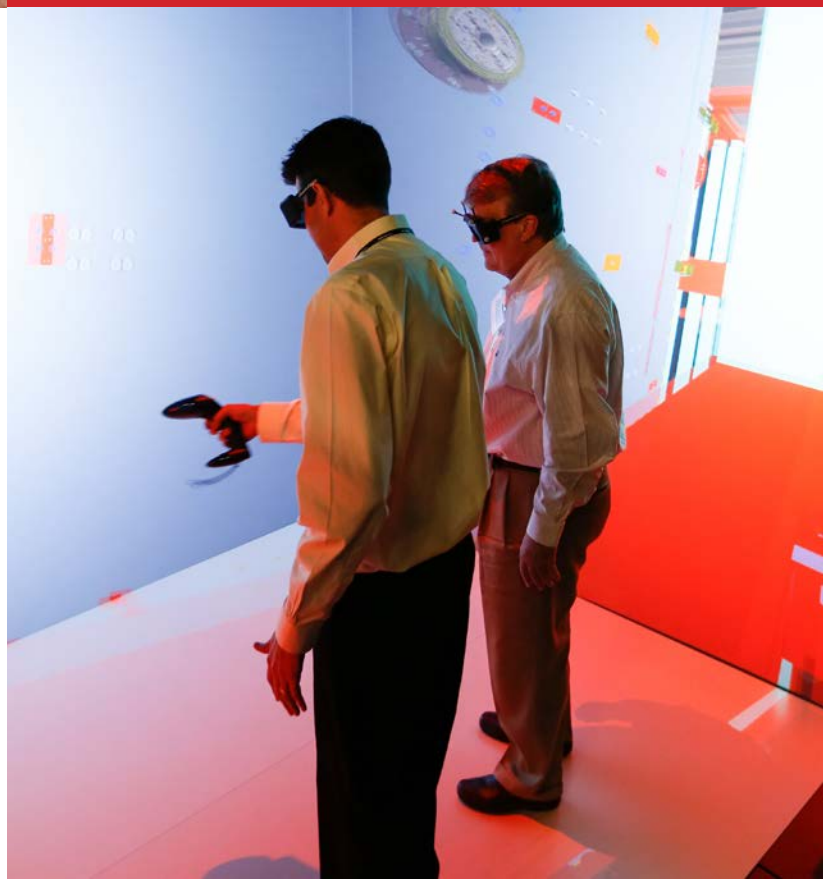
Shown left to right in front of Orion's aft bulkhead are Dr. Suren Singhal, Dr. Richard Koubek, Patrick Scheuermann, Jeff Pilet, Tim Livingston, Dr. Dava Newman, Dr. Danielle Wood, Bobby Watkins, Mark McCloskey, Mike Kynard and Johnny Stephenson.

ORION, MEET ST. LOUIS

On Sept. 2, former Orion Program Manager Mark Geyer threw out the ceremonial first pitch and presented the St. Louis Cardinals Hall of Fame and Museum with a flown memento from last December's Exploration Flight Test-1. While in St. Louis, Geyer shared information about Orion's next flight on Exploration Mission-1 with Cardinals Nation fans and also spoke to hundreds of students at the St. Louis Science Center about NASA's Journey to Mars.

EXPERIENCING ORION... VIRTUALLY

On Sept. 21, U.S. Representative John Culberson (R-TX) toured Lockheed Martin's Waterton facility in Littleton, Colorado. Pictured here is Lockheed Martin Engineering Manager Darin Bolthouse (left) providing the congressman with a virtual reality demonstration of the Orion assembly in the company's Collaborative Human Immersive Laboratory (CHIL). During the tour, Orion Deputy Program Manager Larry Price also provided a status update on Orion's progress toward Exploration Mission-1. The CHIL is an advanced technology virtual reality and simulation laboratory that offers a smarter, cheaper and lower risk opportunity in building the actual spacecraft. Using the CHIL, Orion engineering can optimize product designs and processes virtually before releasing them to manufacturing to help improve material flow, producibility and mitigate program risk.



ORION TEAM MEMBERS COMMENDED FOR INNOVATION

Several Orion employees and teams received recognition during the 2015 Johnson Space Center (JSC) Honor Awards Ceremony on Sept. 23.

The Director's Commendation Award, which recognizes JSC employees who have provided significant contributions to the center throughout the year, was given to Teresa Murphy, Richard Schmidgall, Michael Thompson, Keith Williams, Barbara Zelon, Steven Del Papa, Paul Felker, Brian Hoelscher, Greg Holt, Jeremy Jacobs, Mark Kane and Karen Kelldorf.

Leonard Cassady (Jacobs Technology) and Nathan Moore received the individual Director's Innovation Award. The Director's Innovation Team Award went to the EFT-1 Joint Test & Mission Operations Systems Team, the Parachute Pendulum Action Team and the JSC Acoustics Office Team. And Robert Crain (Ares Technical Services) received the Power of One Gold Award.

THE MARTIAN MOVIE AND OUR JOURNEY TO MARS

The film "The Martian" takes the work NASA and others have done exploring Mars and extends it into fiction set in the 2030s, when NASA astronauts are regularly traveling to Mars and living on the surface. NASA has collaborated on this film with 20th Century Fox Entertainment, providing guidance on production design and technical consultants. Across NASA, dozens of people are already working on the technologies humans will need when they begin to explore Mars.

▶ Read the full story

Orion is a key piece of NASA's journey to Mars. The spacecraft, which was first tested in space last year, will enable crew to travel to deep space on the journey to the Red Planet and bring astronauts home safely. It's a critical technology we will use to help NASA test, demonstrate and hone the skills and capabilities we need to operate farther and farther away from Earth.

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OCTOBER:

Orion Critical Design Review

Exploration Mission -1 crew module barrel to aft bulkhead weld at Michoud Assembly Facility

Orion crew egress training at Neutral Buoyancy Lab

Orion zero-g crew training