

National Aeronautics and  
Space Administration



# ORION

NOVEMBER 2015

**NASA AND  
EUROPEAN  
PARTNERS SET  
TO EVALUATE  
SERVICE MODULE  
TEST ARTICLE**



# TEST VERSION OF EUROPEAN POWERHOUSE FOR ORION ARRIVES STATESIDE

A critical component that will enable humans to explore deep space in NASA's Orion spacecraft arrived in Cleveland, Ohio, on Nov. 9 on one of the world's largest aircraft. A full-size test version of Orion's service module, provided by the European Space Agency (ESA) was delivered to Cleveland Hopkins Airport on an Antonov AN-124.

Built by ESA prime contractor Airbus Defence & Space and integrated by NASA prime contractor Lockheed Martin, Orion's service module will provide in-space propulsion and power, as well as air and water for the crew. Over the next several months, testing will take place at the Space Power Facility at NASA Glenn Research Center's Plum Brook Station to validate the engineering analysis. The power-generating solar arrays that will provide up to 11kW of energy for the crew module, will be tested to ensure the panels deploy properly. The large vibration table and acoustic chamber will simulate the shaking and noise the service module will experience during its ascent into space. Pyrotechnics will be used to simulate the shock the service module will experience during separation from the Space Launch System rocket. Results from the test data will ensure flight hardware will perform to NASA's safety and flight requirements.

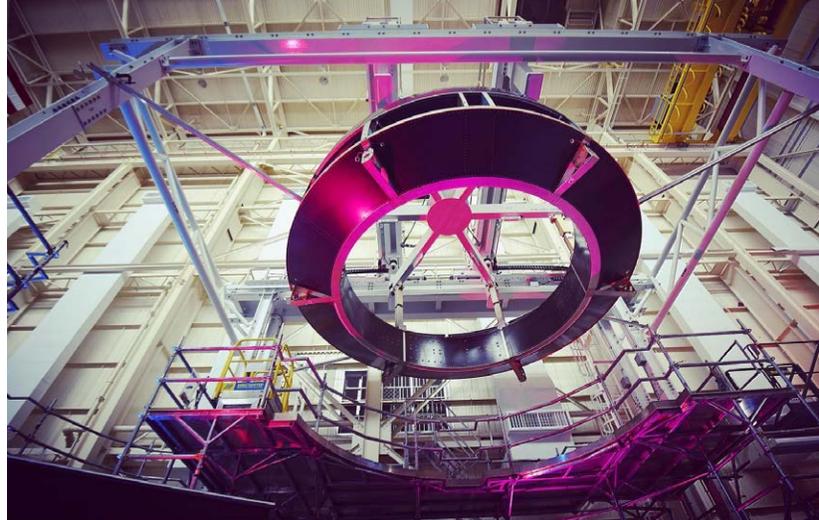
NASA's Plum Brook Station is home to some of the largest testing structures in the world, including the powerful space environment simulation facilities and vacuum chamber. Also at Plum Brook is the world's most powerful spacecraft acoustic test chamber, and the world's highest capacity and most powerful spacecraft vibration table.

- ▶ [NASA Web Story](#)
- ▶ [Airbus Defence and Space News Release](#)

Orion in the news:

- ▶ [NASA's Orion Project Begins Testing in Sandusky](#)
- ▶ [Piecing Together Orion](#)

**NASA and Lockheed Martin leadership joined the ESA and Airbus team at NASA Glenn Research Center's Plum Brook Station in Sandusky, Ohio, on Nov. 30 to mark the beginning of the testing phase for the structural representation of Orion's service module.**



When it comes to enduring the extremely hot and fast journey from deep space back to Earth, NASA's Orion spacecraft can withstand the heat. Engineers developing Orion's thermal protection system have been improving the spacecraft's heat shield design and manufacturing process since the vehicle successfully completed its first flight test last year. They are now enhancing the overall system in advance of the spacecraft's next mission – a flight that will put Orion through the harshest set of conditions yet.

On future Orion missions, a silver, metallic-based thermal control coating will be bonded to the crew module's back shell tiles. The coating, similar to what is used on the main heat shield, helps reduce heat loss when Orion is pointed to space and therefore experiencing cold temperatures. It also limits the high temperatures the crew module will be subjected to when the spacecraft faces the sun.

Engineers have also refined the design in ways that improve the manufacturing process and reduce the mass of the spacecraft. Instead of a monolithic outer layer, the heat shield will be made of approximately 180 blocks that can be made simultaneously with the other heat shield components to streamline the manufacturing process.

In addition, engineers have found ways to reduce the mass of the heat shield's underlying structure, which is composed of a titanium skeleton and carbon fiber skin. This adds more fidelity to the overall structure while allowing it to be lighter.

► [Read the full story](#)

A detailed illustration of the Orion spacecraft in space. The spacecraft is shown from a low-angle perspective, highlighting its large, metallic heat shield and the crew module. The background is a deep blue space with a view of Earth's horizon at the bottom. The text 'PUTTING THE SHINE ON THERMAL PROTECTION' is overlaid at the bottom in large, bold, white letters.

# PUTTING THE SHINE ON THERMAL PROTECTION

NASA's Super Guppy aircraft appears to swallow up a test structure during a loading operation at the Shuttle Landing Facility at NASA's Kennedy Space Center in Florida. The Orion spacecraft service module stacking assembly interface ring and stack holding stand were secured to a special transportation platform and loaded into the Super Guppy for a Nov. 3 transport from Kennedy to NASA Glenn Research Center's Plum Brook Station in Sandusky, Ohio.

# SUPER GUPPY GULP



## ORION INGENUITY IMPROVES MANUFACTURING, REDUCES MASS

Orion's pressure vessel holds the atmosphere in the crew compartment, enabling astronauts to survive in the vacuum of deep space. The pressure vessel is composed of seven large pieces of aluminum, three of which are the cone panels.

As engineers refined Orion's design, building on lessons learned from constructing the initial test article and crew module for Exploration Flight Test (EFT-1), they found ways to reduce the number of cone panels and welds, resulting in a needed weight reduction for EM-1.

When completed, the crew module will be approximately 20 percent (4,000 pounds) lighter than it was during EFT-1.

► [Read the full story](#)



At NASA's Michoud Assembly Facility in New Orleans, engineers used large tooling structures to help them weld together Orion's cone panels using friction-stir welding.



NASA is testing the spacesuits being developed for Orion on the agency's C9 aircraft, which can fly a series of parabolas to simulate a weightless environment for brief periods. Engineers used a mockup of Orion's cabin in the aircraft to evaluate how astronauts can get into their seats during various operational scenarios, perform tasks at different suit pressures, and to test seat hardware. The suit, known as the Modified Advanced Crew Escape Suit, is an upgraded version of the launch and entry suits worn by space shuttle astronauts. The crew escape suit, along with Orion, will contain all the necessary functions to support life and is being designed to enable spacewalks and sustain the crew in the unlikely event the spacecraft loses pressure.

# ORION SPACESUITS TESTED IN REDUCED GRAVITY



# AEROJET ROCKETDYNE COMPLETES BUILD OF 3-D PRINTED PARTS FOR ORION SPACECRAFT

## ORION SOFTWARE NAVIGATES TO SUCCESS

On Dec. 5, 2014, Orion launched atop a Delta IV Heavy rocket for a four-hour-long, two-orbit extended journey around Earth, testing many of the systems most critical to safety. One element that passed with flying colors is Orion's Guidance, Navigation and Control (GN&C) software. This software recently earned NASA's 2015 Software of the Year honor.

As most people who witnessed the flight test know, Exploration Flight Test-1 was a resounding success. What wasn't seen, though, toiling in the background—was the GN&C software that guided, navigated and steered the spacecraft throughout all phases of the flight.

The software functioned flawlessly throughout the mission, without any ground commands, and landed the crew module within a half mile of the intended landing site in the Pacific Ocean.

The software was developed through a joint effort with two teams: the Orion GN&C team and the Orion Flight Software team.

Orion's GN&C team is unique. Government team members work with Lockheed Martin, the Orion prime contractor, on integrated Multi-Organizational Development Engineering teams. This award recognizes 82 engineers crucial in the maturation of the software, including members from JSC's Engineering and Flight Operations directorates, Langley Research Center employees and eight other contractor companies.

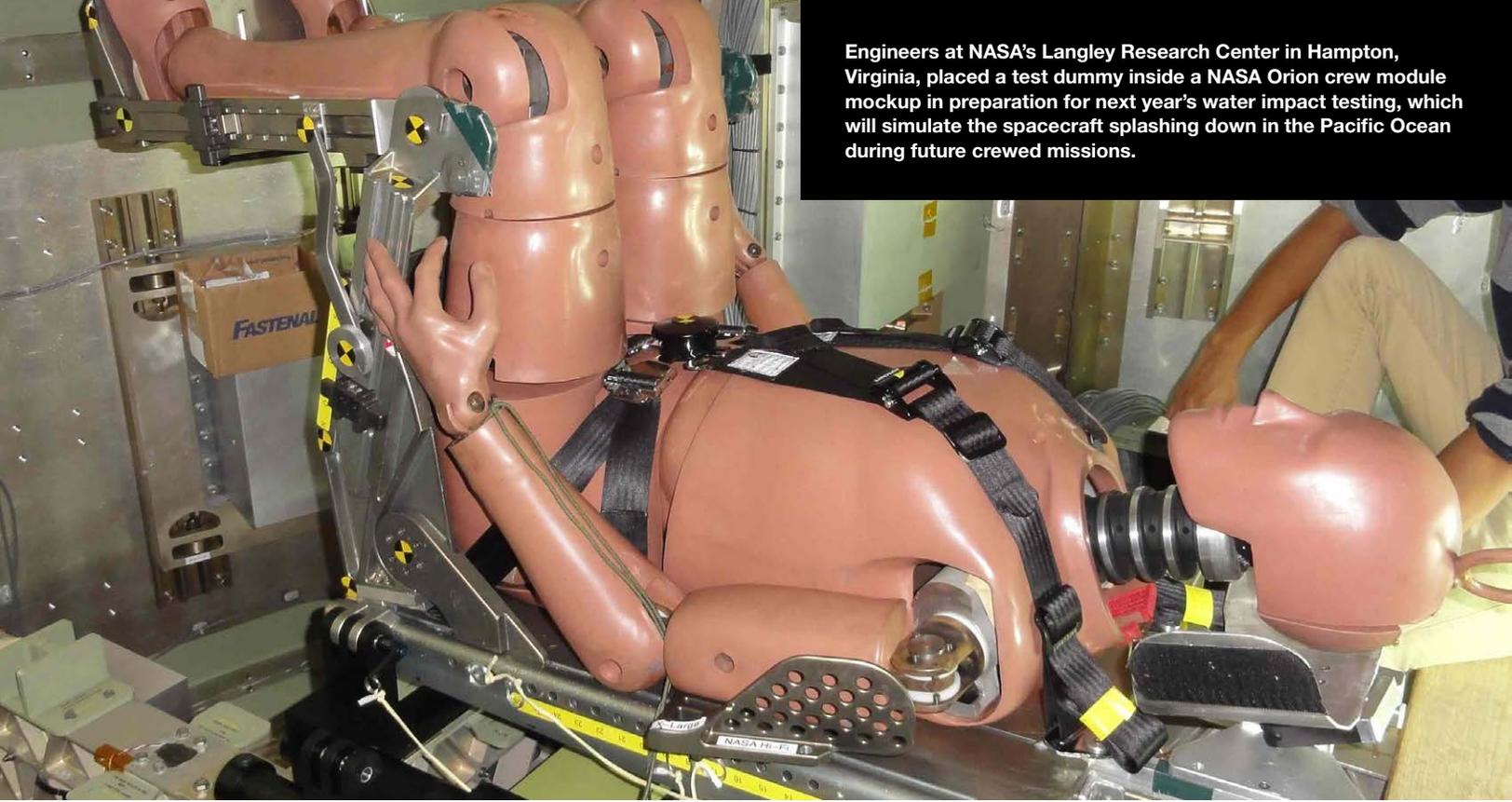
Aerojet Rocketdyne has completed 12 additively manufactured production nozzle extensions for use aboard the Orion spacecraft. The nozzle extensions are part of Orion's crew module reaction control system that Aerojet Rocketdyne is building for Lockheed Martin and NASA.

The 12 nozzles were produced on a single additive manufacturing machine in just three weeks, which represents a roughly 40 percent reduction in production time when compared with using conventional manufacturing techniques. The company will next conduct a series of inspections and hot-fire tests to qualify the components for use aboard Orion's Exploration Mission-1 test flight in 2018.

The reaction control system provides the Orion crew module with the ability to control its course after it has separated from the service module. Additionally, during Orion's reentry into the Earth's atmosphere, it ensures that 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 use of additive manufacturing technology, often referred to as 3-D printing, reduces the cost to produce components, shortens build times and unleashes engineers to design components that were once impossible to build using traditional manufacturing techniques.

Engineers at NASA's Langley Research Center in Hampton, Virginia, placed a test dummy inside a NASA Orion crew module mockup in preparation for next year's water impact testing, which will simulate the spacecraft splashing down in the Pacific Ocean during future crewed missions.



# ENGINEERS PREPARE FOR ORION WATER-IMPACT TESTING WITH PRECISION TO PROTECT FUTURE ASTRONAUTS

When astronauts return to Earth in the Orion spacecraft, they will reenter on an extremely hot and fast journey through the atmosphere before splashing down in the Pacific Ocean. To protect the crew on landing, NASA will evaluate how the spacecraft may behave in parachute-assisted landings in different wind conditions and wave heights by conducting water-impact testing.

To prepare for this testing, the first major step at NASA's Langley Research Center in Hampton, Virginia, was to couple an Orion crew module mockup with the heat shield from the spacecraft's first flight test, Exploration Flight Test 1 (EFT-1).

To create perfect unity, the team had to design and fabricate integration hardware to connect the two pieces. With an accuracy of four thousandths of an inch, a laser tracker located several positions along the Orion mockup and heat shield in order to achieve nearly perfect alignment.

At the same time, the team prepared the remainder of the

mockup for water-impact testing. The team then installed the crew seats and the crew impact attenuation system that is designed to lessen the shock load on astronauts during landing.

Two test dummies were also installed in the crew seats. Data retrieved from sensors inside the dummies during testing will be used to evaluate the loads the crew may experience during an actual mission, which will aid in designing the systems to protect the crew from injury during water landings.

Nine drop tests of the integrated Orion mockup and EFT-1 heat shield will be conducted at Langley next year. These tests are but one of the many steps necessary to ensure that NASA's new spacecraft will meet the demands of sending humans to deep space for the first time and in the future on the journey to Mars.

► [Read the full story](#)



# SHAKE, RATTLE AND ROLL!

In the Acoustic Vibration Lab at Lockheed Martin's Space Systems Company headquarters in Littleton, Colorado, engineers have begun a series of vibration tests on the astronauts' display console for Exploration Mission-1. Pictured here is a mass simulator of the display console mounted with six isolation struts to two shaker tables. The shaker tables will simulate the harsh environments experienced by the console during different mission events such as liftoff, ascent, abort, landing and drogue parachute mortar firing. The data from these tests will be used to evaluate the console's vibration and movement, as well as the performance of the isolation struts.

## ORION, JOURNEY TO MARS: NEW EXHIBIT AT DISCOVERY SCIENCE PLACE



## ORION TEAM SUPPORTS ENDEAVOURFEST

Space Shuttle Endeavour was the focus of a celebration at Los Angeles' California Science Center. The event, held Oct. 30-Nov. 1, commemorated the third anniversary of the shuttle's delivery to the Samuel Oschin Pavilion with a three-day celebration featuring special exhibits and guest speakers. The Orion, Space Launch System and Ground Systems Development & Operations programs were highlighted in a large exhibit that included staff from each of the programs to engage guests. Local Orion subcontractors from Aerojet Rocketdyne and Coast Aerospace Manufacturing also supported the event by staffing the NASA/Orion exhibit.



On Nov. 5, NASA Orion Engineer Stu McClung visited the Discovery Science Place in Tyler, Texas, to open the Orion Exhibit Hall and give a presentation on the Orion Program.

► [Read the full story](#)



# A CELEBRATION OF NASA HUMAN SPACEFLIGHT

NASA's Exploration Systems Development leadership hosted an informal evening reception for the NASA human spaceflight team at the Johnson Space Center's Saturn V Building in Rocket Park on Nov. 5. The event recognized the contributions of leaders who have taken the spirit of human spaceflight to new opportunities at NASA.

**Former Orion Program Manager Mark Geyer receives leadership award from Deputy Associate Administrator for Exploration Systems Development Bill Hill.**

## ORION PROGRAM MANAGERS VISIT ALMA MATERS

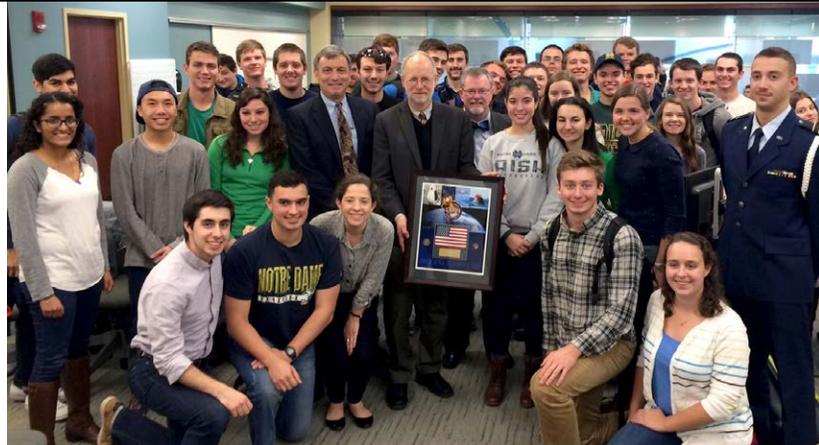
On Nov. 11, Lockheed Martin Orion Program Manager Mike Hawes and NASA Orion Program Manager Mark Kirasich visited the University of Notre Dame to provide an Orion program update to an audience of 125 in the Aerospace Engineering Department and present EFT-1 flown items to the university.

Lockheed Martin Orion Program Manager Mike Hawes and NASA Johnson Space Center Deputy Director Mark Geyer provided Orion program updates and presented EFT-1 flown items, along with Lockheed Martin's J.R. Edwards, to Purdue University and Purdue University Libraries during their visit on Nov. 10.

**TOP-RIGHT: Notre Dame's Dr. Gretar Tryggvason and engineering students join alumni Mark Kirasich and Mike Hawes at the University of Notre Dame.**

**MIDDLE-RIGHT: Notre Dame alumni Kirasich and Hawes, present an EFT-1 patch flown on Orion to Dean Kilpatrick, College of Engineering.**

**BOTTOM-RIGHT: Tracy Grimm of Purdue Libraries shows Hawes, Geyer and Edwards some of the 452 boxes of Neil Armstrong documents and artifacts. The Purdue Libraries contain memorabilia from every NASA human spaceflight program.**





## ALL ABOUT OLIVER

An Orion Backstage video features Oliver Juckenhöfel, head of the Orion Service Module program for Airbus Defence and Space, who talks about the arrival of a structural representation of the European service module at Plum Brook Station.

► [View the video](#)



The Orion Trial by Fire video, produced by the External Relations Office's John Streeter, won an Emmy Award.

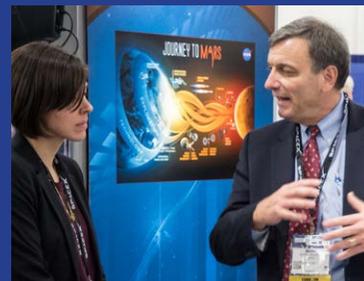
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# ORION TEAM SUPPORTS SPACECOM 2015



NASA and Lockheed Martin were among the founding supporters for the inaugural SpaceCom event held Nov. 17-19 in Houston. More than 1,700 attendees from around the world participated in three days of conference and exposition events that were engineered to fuel business innovation across the aerospace, medical, energy, transportation, maritime, communications and advanced manufacturing industries.

Dr. Ellen Ochoa, NASA Johnson Space Center director, and Wanda Sigur, Lockheed Martin vice president & general manager, Civil Space, presented a flag flown on Orion's Exploration Flight Test-1 to the City of Houston at the opening ceremony of the conference. Sigur also participated on a panel entitled, "The State of Global Space Commerce," with other industry experts. Tony Antonelli, Lockheed Martin's Exploration Systems Chief Technologist, introduced keynote speaker Dr. Yuri Sebregts, and members of the Orion and Space Launch System teams presented an update on the future of human space exploration in the Innovation Theater.



## FOLLOW THE PROGRESS OF NASA'S NEW SPACECRAFT FOR HUMAN EXPLORATION:

**NASA's Orion Blog**..... [Blogs.NASA.gov/Orion](http://Blogs.NASA.gov/Orion)

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# DECEMBER:

**Welding Continues at Michoud Assembly Facility**

**Human-in-the-loop Testing at Johnson Space Center**

**Orion Backshell Panel at Space Center Houston**

**MSK Supplier Visit**