ORION

DECEMBER 2018

Keeping Orion Upright After Splashing Down

KEEPING ORION UPRIGHT AFTER SPLASHING DOWN

As NASA progresses toward Exploration Mission-1, the first flight of its Orion spacecraft and Space Launch System rocket, engineers are ensuring every system in the spacecraft can endure the harsh environment of space thousands of miles from home and safely return to Earth.

A team at NASA has been working to perfect the last spacecraft system to deploy – the airbags on top of the crew module – which will reorient the capsule and keep it upright and stable after splashdown in the ocean and potentially through rough waves or high winds.

Engineers have implemented a series of improvements on the system to upright the spacecraft since Orion's successful flight test in space in 2014. During the flight test, three of the system's five bags did not properly inflate, though the spacecraft remained upright in the water. Improvements include thickening the inner bladder of each round airbag to make it more durable, changing how the bags are packed, and developing a harder cover.

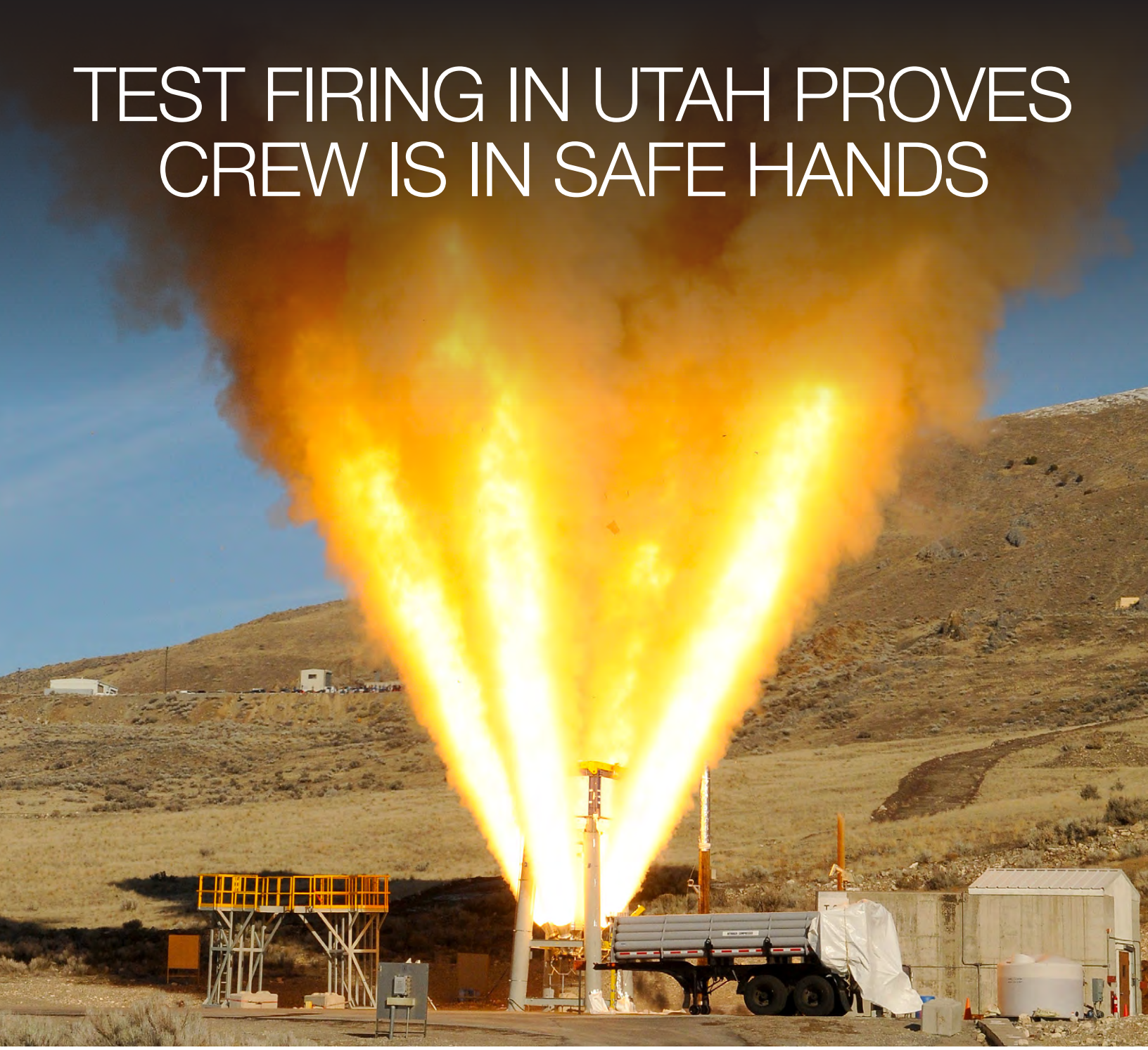
The Orion Crew Module Uprighting System (CMUS) consists of five bags that are packed tightly in containers and stored atop the Orion capsule. After landing, the bags deploy from the same area where landing and recovery systems, such as parachutes and beacons, are stowed. This area also contains protrusions and sharp edges that could potentially snag the bags or tethers that keep the bags attached to the spacecraft. The upgrades and testing further demonstrate the system can work in these delicate conditions.

In early December, the CMUS and Neutral Buoyancy Laboratory teams at Johnson Space Center successfully completed two tests off the coast of Galveston, Texas, that were instrumental in validating the bags performed as intended. The two test cases covered scenarios where only four of five bags inflated.

NASA partnered with the United States Coast Guard and Air Force, and Texas A&M Galveston teams to perform the tests.

Next year, the team will test the uprighting system in the ocean where rougher wind and wave conditions are more like those expected when Orion lands approximately 50 miles off the coast of San Diego after returning from deep space.

TEST FIRING IN UTAH PROVES CREW IS IN SAFE HANDS



Northrop Grumman, along with NASA and Lockheed Martin, successfully performed a ground test firing of the launch abort motor for NASA's Orion spacecraft's Launch Abort System on December 13 in Promontory, Utah.

The 17-foot-long, three-foot-diameter abort motor burned out in five seconds, about three to four times faster than a typical motor of its size. This high-impulse motor is designed to burn most of the propellant within the first three seconds to immediately deliver the needed thrust to pull the crew module safely away from danger. As expected, the motor reached just under 370,000 pounds of thrust in one eighth of a second—enough thrust to lift 66 large SUVs off the ground. If needed during a launch mishap, the crew module would accelerate from zero to 400-500 mph in two seconds.

This Qualification Module (QM) test, designated QM-2, was a critical milestone toward qualification of the motor that will safely pull the Orion crew module away from NASA's Space Launch System (SLS) rocket in the event of an emergency on the launch pad or during ascent. QM-2 brings Orion one step closer to its first flight atop NASA's SLS, eventually enabling humans to explore destinations beyond low-Earth orbit.

Watch a Facebook Live of the event and hear from experts: **bit.ly/Dec18QM2**

ASCENT ABORT-2 REACHES FINAL DESTINATION

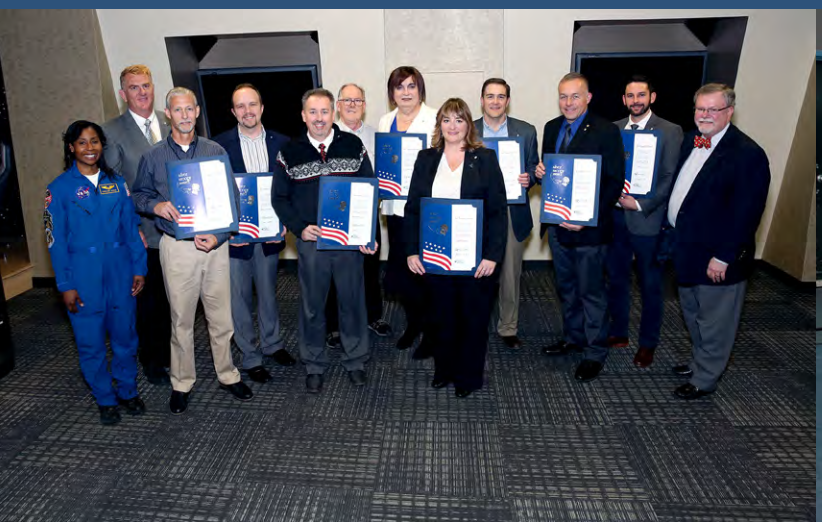
The engineering team at NASA's Johnson Space Center in Houston completed an Orion milestone by equipping the crew module for a crucial abort system flight test, Ascent Abort-2 (AA-2), and transporting it to the Kennedy Space Center in Florida.

The test crew module, complete with its newly attached separation ring that serves as its interface to the abort test booster, was prepped and loaded on a truck for its four-day trek to Kennedy on Dec. 1. The flight article is protected by multiple layers of shrink-wrap and tarps to withstand road hazards and inclement weather.

The importance of the AA-2 test is to verify that, in the event of an emergency during ascent, Orion's Launch Abort System (LAS) can fire within milliseconds to pull the crew module away from the launch vehicle and reorient the spacecraft for a safe landing. A full-stress test of Orion's LAS is planned for May 2019 from Cape Canaveral Air Force Station.

Once at Kennedy, the AA-2 test crew module will first be integrated with the LAS and tested to ensure functionality. That flight test article will then be transported to the pad to be stacked atop its test booster in preparation for flight.

ORION TEAMS DESERVING OF RECOGNITION



Space Flight Awareness Silver Snoopy awardees receiving their awards from Astronaut Stephanie Wilson in Denver.

Orion Program Managers Mark Kirasich (NASA) and Mike Hawes (Lockheed Martin) recently visited the Lockheed Martin Waterton facility in Littleton, Colorado, to provide a program status update to employees. Kirasich also awarded multiple teams and individuals with Orion Program Manager commendations for their outstanding work on the program.

Prestigious Silver Snoopy honors were awarded by NASA Astronaut Stephanie Wilson to Christine Bland, Linda Cuplin, Jerry Draper, Robert Hixson, Ron Johns, David Krajecki, Sean O'Dell, Karl Yeanoplos, Thomas DiCuirci and John Lloyd. Earlier in the year, Astronaut Nicole Mann presented the award to Mark McCloskey and John Masaveg in a ceremony that took place at Michoud Assembly Facility in Louisiana. The Silver Snoopy, which is awarded to fewer than one percent of the aerospace program workforce annually, is

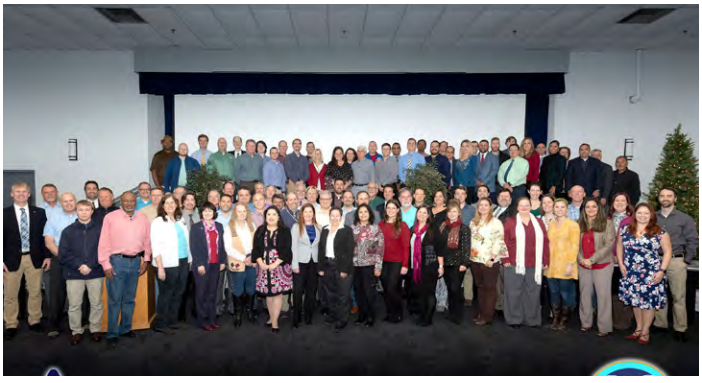
Representatives of the Orion Thermal Analysis Thermal Protection System team receiving a Space Flight Awareness team award.

presented to employees who have significantly contributed to the human space flight program to ensure flight safety and mission success.

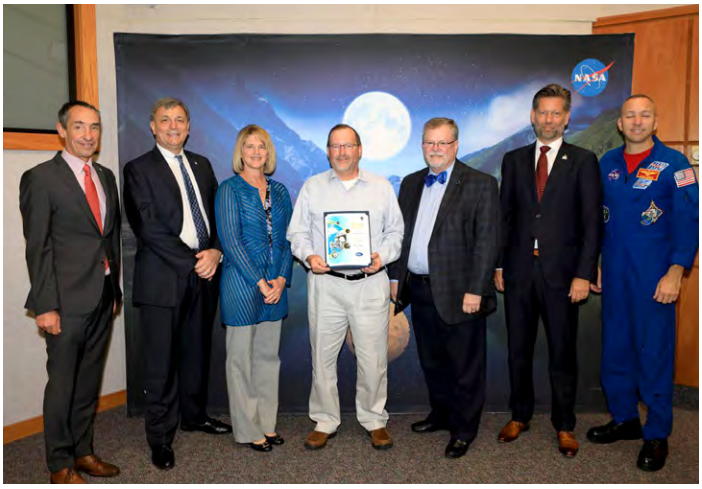
Three Space Flight Awareness (SFA) Trailblazer awards went to Lockheed Martin employees Alex Belt, Christopher Jackson and Andrew Thompson. This award is presented to employees supporting human space flight during the first seven years of their career and have demonstrated strong work ethic and creative, innovative thinking in support of human spaceflight.

SFA team awards were presented to the Orion Structural Test Article Structural Analysis team for their efforts in conducting and completing the structural qualification of the Exploration Mission-1 crew module and the Orion Thermal Analysis

Space Flight Awareness Honorees receiving awards at NASA's 60th Anniversary event.



Representatives of the Capsule Parachute Assembly System team receiving a project commendation for their work.



Representatives of the Made in America team receiving a Space Flight Awareness team award from Astronaut Randy Bresnik.

Representatives from Orion's supplier Avatar receiving a Program Manager commendation for their work.

Thermal Protection System team for designing, developing, testing and certifying the Orion thermal protection system for Exploration Mission-1. Astronaut Randy Bresnik also presented an SFA award at a ceremony at Kennedy Space Center in Florida to recognize the team members who made it possible for the Exploration Flight Test-1 crew module to be featured on the White House front lawn during the Administration's Made in America Product Showcase event in July. The SFA team award recognizes small groups of employees who have demonstrated exemplary teamwork while accomplishing a particular task or goal in support of the human spaceflight program.

Several other team members received SFA awards for exemplary work on Orion including several Lockheed Martin Orion team members who were recognized as SFA Honorees at NASA's 60th Anniversary 2018 events in September: Dean Coleman, Eric Esposito, Lora Lechago, Frank Middleton, Timothy Norick, Robert Ott, Blake Watters and Mike Wells.

Capsule Parachute Assembly System team members were recognized with a project commendation at the end of November for their outstanding work in the development and qualification of Orion's parachute system for crewed flights. In addition, Orion's supplier Avatar Machine, located in Fountain Valley, California, was presented an Orion Program Manager commendation for their contribution to the program in preparation for Exploration Mission-2.

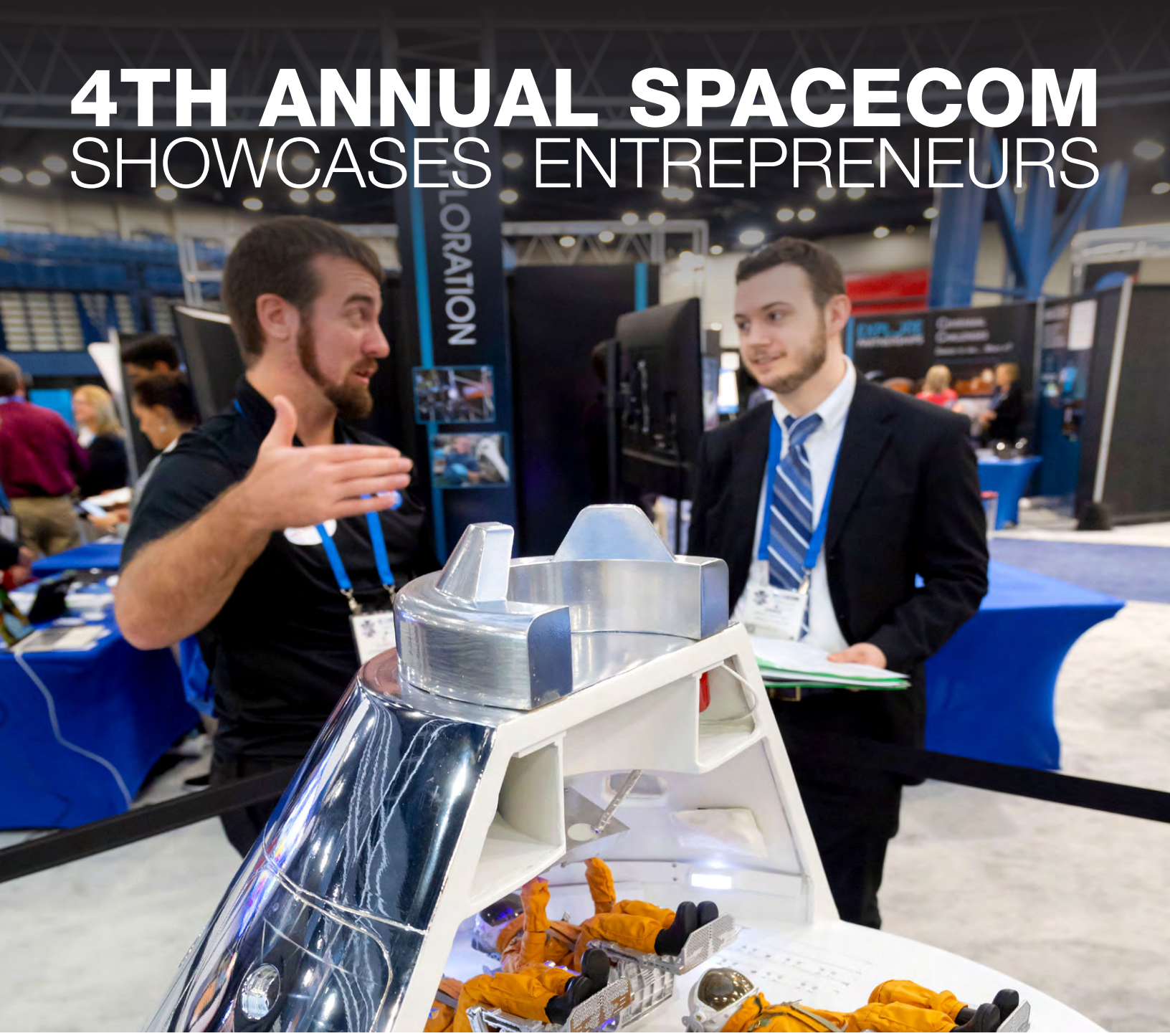
RADIATION SHIELDING PODCAST

Orion's need to block radiation as crewmembers travel into deep space is the focus for Episode 75 of Houston, We Have A Podcast. Matt Lemke, Orion avionics, power and software deputy manager, discusses how Orion is radiation-hardened so the systems inside can withstand the harsh environments of space. This includes systems such as life support, communications, propulsion, navigation and everything else that is controlled by the computer systems inside of Orion, that would malfunction if too much radiation entered the spacecraft.
Listen here: **go.nasa.gov/2SWilyr**

SMALL STEPS, GIANT LEAPS PODCAST

In this first episode of Small Steps, Giant Leaps, Dr. Greg Holt, navigation lead for the Orion spacecraft, discusses how the vehicle finds its way through deep space and communicates with Earth along the way. Listen in to get an insider's view on how we'll track Orion, gather real-time diagnostics, and stay in communication with the spacecraft and its crew as they journey into deep space.
Listen here: **go.nasa.gov/2ST1UTi**

4TH ANNUAL SPACECOM SHOWCASES ENTREPRENEURS

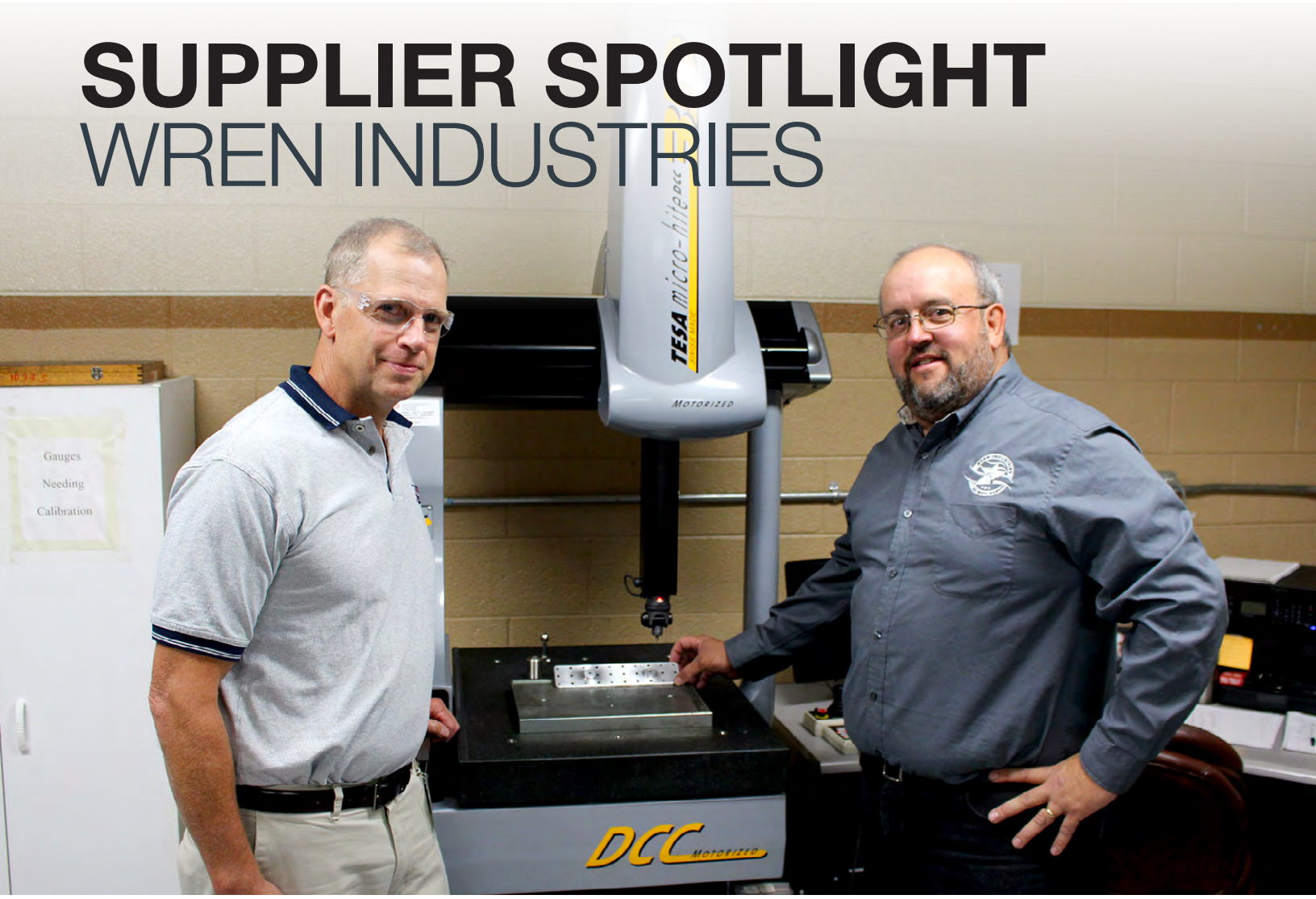


Lockheed Martin and NASA Orion team members supported the 4th annual SpaceCom Expo at George R. Brown Convention Center in Houston Nov. 27-28. The event brought together people from a wide variety of industries from across the country and around the globe with more than 2,200 participants representing 450 organizations from 39 different countries, including leadership from aerospace industry and space agencies such as NASA, India's Antrix Corporation, the Australian Space Agency and the Italian Space Agency. Additional highlights included the National Space Council's Users Advisory Group session and the Global Spaceport Summit with 19 spaceports participating.

Lockheed Martin sponsored the Entrepreneur Summit this year, a new addition to SpaceCom featuring 24 startup companies that exhibited new technologies in the Entrepreneur Pavilion. Jim Crocker, vice chair of the Space Studies Board of the National Academies of Sciences, Engineering, and Medicine and Lockheed Martin Space VP & GM (retired), served as a judge for the semi-final and finalist rounds of the Entrepreneur Challenge competition and presented the top prize for the most innovative presentation. Houston-based Lazarus 3D Inc. won the competition for their utilization of cutting-edge 3D printing technologies that provide the best medical training models for medical professionals to transform surgery training on Earth and in space.

For more information, visit: **spacecomexpo.com**

SUPPLIER SPOTLIGHT
WREN INDUSTRIES



Mike Sneddon, president of Wren Industries, shows Art Maples from NASA a wiring plate which will be installed on Orion's EM-1 spacecraft.

Wren Industries provides a much-needed capability that helps technicians respond and react quickly while an Orion spacecraft is being assembled in the Operations & Checkout Building at Kennedy Space Center. Wren Industries has provided a variety of parts from full 5-axis machine components to precision shims. Orion continues to break barriers with human capable spacecrafts, but it still uses some of the same techniques originally developed during the Apollo program. Every now and again you need carefully crafted shims - built to the same exacting specifications as the structural components themselves - to ensure a proper fit and alignment. Wren provides these shims which allow critical components to fit in their final locations properly as part of the Exploration Mission-1 and 2 crew modules as well as the structural test articles. The Orion Program is their first opportunity to support NASA.

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