National Aeronautics and
Space Administration

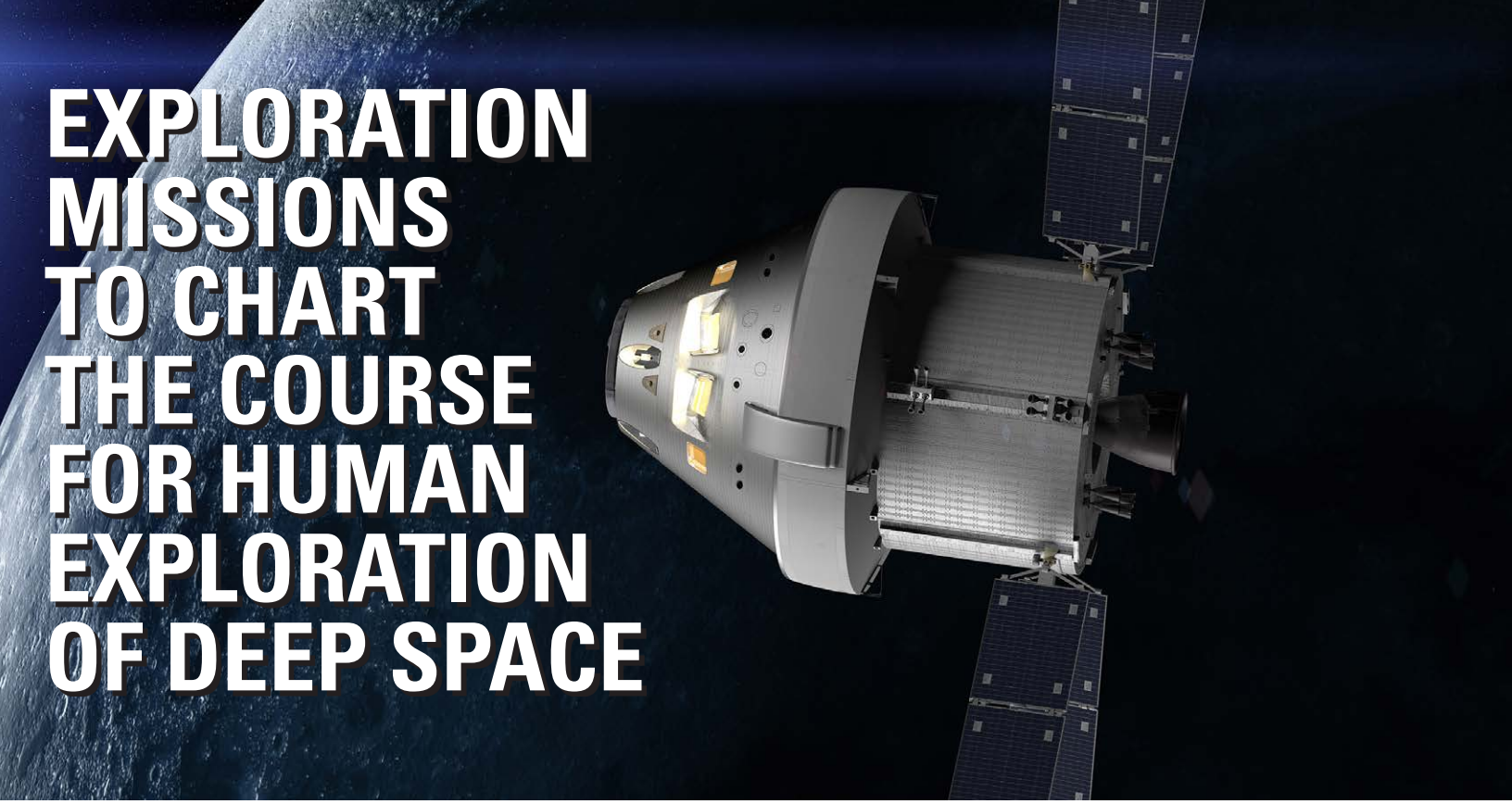
ORION

NOVEMBER 2016

ENTERING THE PROVING GROUND OF SPACE

ORION'S MONTHLY HIGHLIGHTS

EXPLORATION MISSIONS TO CHART THE COURSE FOR HUMAN EXPLORATION OF DEEP SPACE



The early missions for NASA's Deep Space Exploration Systems will pave the way for future missions over the next several decades. On Exploration Mission-1, the Orion spacecraft will be launched by the Space Launch System (SLS) and travel more than 40,000 miles beyond the moon to an area that is only about three to five days away from Earth, yet farther than any of the Apollo astronauts ever traveled. With flight hardware already in production for the first two Exploration Missions, NASA has established integrated human exploration objectives combining the efforts aboard the International Space Station, SLS and Orion, and other capabilities needed to support human missions on the journey to Mars.

The journey to Mars crosses three thresholds, each with increasing challenges as humans move farther from Earth, starting with Earth reliant exploration aboard the space station in low-Earth orbit, through the proving ground of cislunar space, and culminating with Earth independent exploration where human missions to the Mars system are possible. The exploration objectives are grouped into three cross-cutting categories, transportation, working in space, and staying healthy, which will support human exploration in deep space throughout the thresholds.

Work is already underway on an initial set of objectives in low-Earth orbit to mature many systems needed for deep space habitation and exploration. Proving ground missions will build on those accomplishments in two phases that will demonstrate our exploration systems and validate our exploration capabilities. These objectives will inform future flight test objectives and enable planners to begin building the detailed profiles and trajectories for the missions in the near-term through the end of the 2020s.

The period of exploration in the proving ground will begin with the first integrated launch of SLS and Orion, (Exploration Mission-1) anticipated in 2018, and will extend through the 2020s. The first phase will focus on demonstrating the safe operation of the integrated SLS rocket and Orion spacecraft and other exploration operations to support short-duration objectives in cislunar space.

The second phase will confirm that the agency's capabilities can perform for long duration Mars class missions and will culminate at the end of the 2020s with a one-year mission in cislunar space before venturing on crewed missions beyond the Earth-moon system.

What we learn in the proving ground will pave the way for Earth independence by helping break our reliance on the logistics and supply chain, and reduce our dependence on ground control. This stage will enable explorers to identify and pioneer innovative solutions to technical and human challenges that could only have been discovered or engineered in deep space.

Read the full story: **go.nasa.gov/2huANOY**

Watch the Orion Backstage food lab video featuring NASA Orion engineer Jessica Vos and food scientist Takiyah Sirmons: **bit.ly/2gKmarh**

SPACE FOOD BARS WILL KEEP ORION WEIGHT OFF AND CREW WEIGHT ON

When astronauts in the Orion spacecraft travel beyond the moon to explore deep space destinations, they'll need a robust diet to keep them healthy and sharp. Feeding the crew on deep-space missions presents several unique challenges that NASA scientists are working to tackle.

Orion has limited room inside it to accommodate the supplies astronauts will need during their missions. Because flights to deep space will not rely on resupply spacecraft to deliver what astronauts need and dispose of trash, the Orion crew will have to take everything they need with them and bring it all back home.

To help reduce the amount of supplies Orion will carry for its crew, scientists are developing a variety of food bars that astronauts can eat for breakfast during their spaceflight missions. In the United States, it's common for people to substitute an energy bar or shake for breakfast, or to skip the meal all together. Food scientists determined that developing a single calorically dense breakfast bar can help meet mass reduction requirements.

The food bars, which are being developed in coordination with NASA's Human Research Program have been tested by crew members inside HERA (Human Exploration Research Analog), the agency's three-story habitat at Johnson Space Center designed to serve as an analog for the isolation and remote conditions in exploration scenarios. The ground-based missions have provided helpful feedback on the flavor, texture and long-term acceptability of the bars that food scientists are using to hone the range of options available.

While scientists continue to improve the food bars and expand the variety of options available, NASA also is working to develop regenerative ways to feed the crew on longer missions, including on the journey to Mars. Scientists are also looking at packaging food items to keep them edible and nutritious in conditions where there are temperature fluctuations, such as the surface of Mars.

Read the full story: **go.nasa.gov/2gnd1Ae**

SOLAR ARRAYS: TAKE TWO

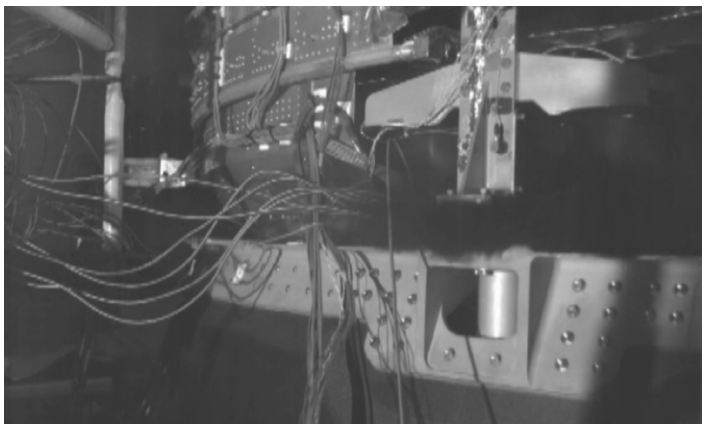
ESA (European Space Agency), Airbus Defence and Space, and NASA service module team successfully completed the second solar panel deployment test at NASA Glenn's Plum Brook Station. The deployment test was conducted after a series of acoustic and vibration tests to ensure the arrays will successfully deploy on orbit after being launched on the powerful Space Launch System rocket.

ORION'S SHOCK FACTOR

Engineers recently completed pyroshock testing with a full-scale test version of the Orion service module at the Space Power Facility at NASA Glenn's Plum Brook Station. During the tests, engineers fired powerful pyrotechnics to simulate the shocks the service module will experience as Orion separates from the Space Launch System rocket.

The service module is an essential part of the spacecraft. It will propel, power and cool Orion during spaceflight in addition to providing air and water for the crew.

Watch video of the testing: **bit.ly/2hx60yb**



ORION'S CREW MODULE ADAPTER GETS A LIFT

The Orion crew module adapter (CMA) for EM-1 was lifted for the first and only time, Nov. 11, during its processing flow inside the Neil Armstrong Operations and Checkout Building high bay at the agency's Kennedy Space Center in Florida.

Technicians with Lockheed Martin, the Orion crew module manufacturer, lowered the adapter onto a test stand for secondary structure outfitting. The CMA was moved into a temporary clean room at the end of November for propellant and environmental control and life support system tube installation and welding.

Read the full story: **go.nasa.gov/2hmNXgq**

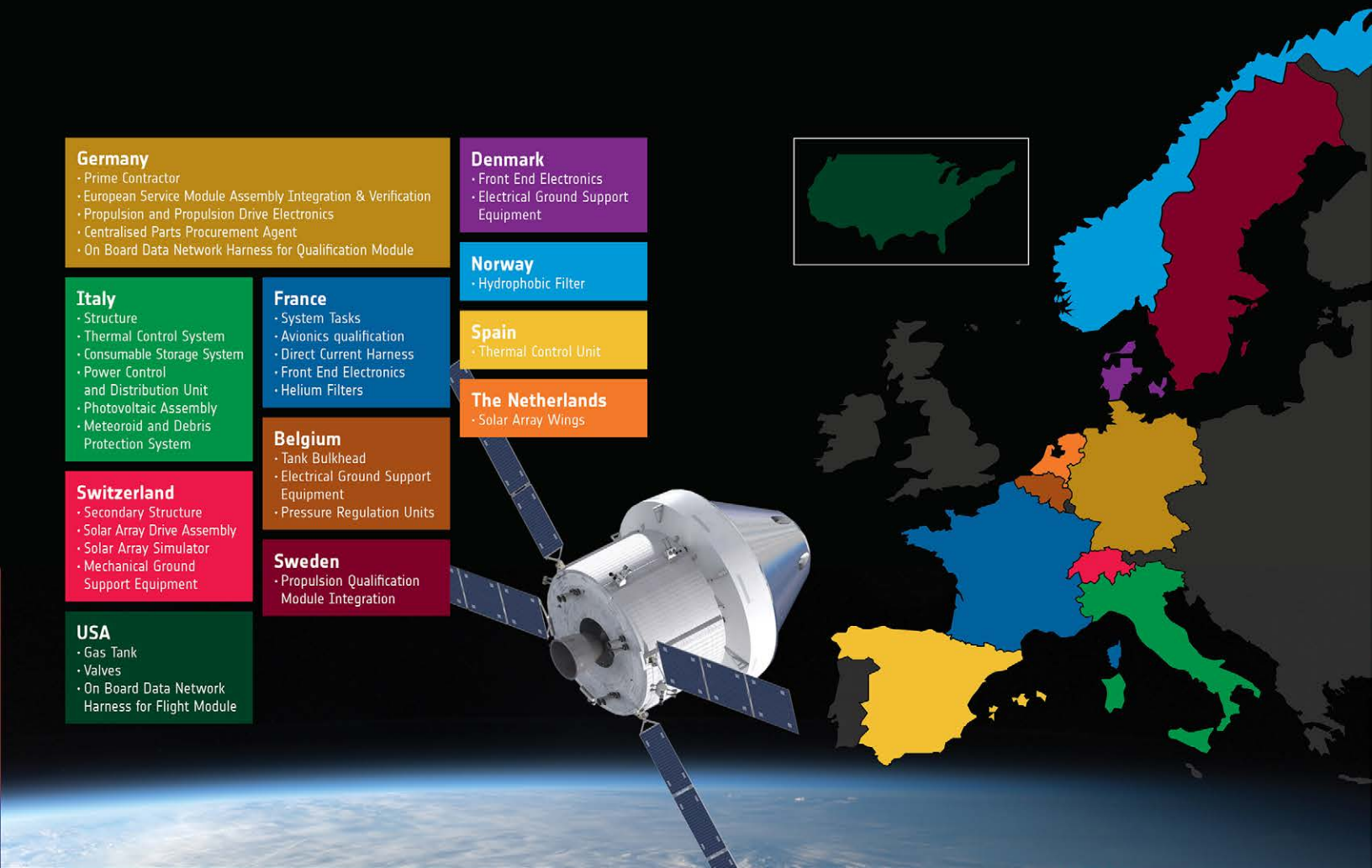
ORION'S EUROPEAN SERVICE MODULE: AN INTERNATIONAL UNDERTAKING

As the first European service module for NASA's Orion spacecraft is being assembled in Bremen, Germany, suppliers all over Europe and the United States are delivering their components that will form the chassis and supply life support and propulsion to the Orion crew module.

Companies from 11 countries have built spacecraft-specific parts for Orion or supplied their proven space hardware to construct the spacecraft that will fly farther than any other human-rated spacecraft.

The prime contractor to ESA (European Space Agency) for the European Service Module is Airbus Defence and Space, a European multinational company that has put its Bremen facility in charge of the service module program. As ESA's direct interface, Airbus is responsible for the complete package, assembling the parts in its Bremen halls and verifying that the components work as expected. The Airbus Orion team orders all parts for the European Service Module, keeps track of orders and ensures parts get shipped to the right place at the right time.

Read more about all the countries involved: **bit.ly/2gKFPYc**



ONE HOT RECOVERY TEST

A functional test of Orion's crew module recovery mechanism (CMRM) was completed in the Panel Test Facility (PTF) at NASA's Ames Research Center in California this month. After Orion missions, recovery personnel will use the CMRM to capture and handle the crew module after it splashes down in the ocean. Since the mechanism must function shortly after splashdown, it can be hot during this operation. The PTF functional test ensured that the CMRM will operate correctly even when still very hot from the heat of re-entry. The test was successful, demonstrating end-to-end CMRM operation at temperatures near 400 degrees Fahrenheit – higher than those expected during an actual Orion mission.

CONGRESSWOMAN SANCHEZ VISITS VACCO IN CALIFORNIA

On Nov. 21, Orion supplier VACCO Industries in South El Monte, California, were honored with a visit from U.S. Congresswoman Linda Sánchez. Rep. Sánchez (CA-38) met with VACCO management for an overview of their Space and Defense businesses then took a tour of the VACCO manufacturing facilities. VACCO Industries Space Product Group designs and manufactures components for the Space Launch System, the Orion spacecraft, the European Service Module, the Interim Cryogenic Propulsion Stage as well as many satellites and space probes.

(Left to right) VACCO management John Habis, Liana Scates, Laura Sheffield, Vince Greco, Congresswoman Linda Sánchez (center), Tony Gonzalez, Greg Wieland and Bret Shelton.

ORION TEAM VISITS BST SYSTEMS

On Nov. 3, several distinguished leaders visited Plainfield, Connecticut-based BST Systems, Inc., an advanced technology company that is supplying hardware for the Orbital ATK-built solid rocket boosters on NASA's Space Launch System (SLS). Speakers included U.S. Representative Joe Courtney (CT-02), NASA astronaut Butch Wilmore and Fred Brasfield, vice president of Program Integration for Orbital ATK's Propulsion Systems division, among others.

The event featured an update on NASA's Journey to Mars from the SLS office at NASA's Marshall Space Flight Center, remarks by Rep. Courtney, and Wilmore sharing stories about being in space. In addition, Brasfield presented BST with an SLS model in recognition for the company's hard work and dedication to the program.

BST Systems is supplying the batteries that will power the avionics and flight safety system on the SLS boosters.

Read *Norwich Bulletin* article: **bit.ly/2hn9wO2**

FAMU JOINS J2M TEAM

Lockheed Martin awarded a $5 million contract to Florida A&M University (FAMU) for a five-year collaboration for research and development work on NASA's Orion spacecraft and future Mars-related projects. A signing ceremony was held on Nov. 16 in the historic Neil Armstrong Operations & Checkout Building at Kennedy Space Center in Florida, where the Orion spacecraft is being assembled and tested for Exploration Mission-1.

Read the *Click Orlando* article: **bit.ly/2ghlYg7**

FAMU is a historically black university that encompasses the Florida A&M University – Florida State University College of Engineering. About 26 percent of engineering majors at FAMU-FSU are women, which exceeds the national average of women enrolled in engineering majors. About 18 to 20 percent of U.S. engineering college students are women, according to the American Society of Mechanical Engineers. Only 14 percent of working engineers are women, according to the Congressional Joint Economic Committee.

NASA HONORS LOCKHEED ORION TEAM

Paul Sannes, Orion Program article manager for Lockheed Martin Space Systems, accepted the 2016 NASA Agency Honor Group Achievement Award, on behalf of the NASA Orion and Lockheed Martin Space Command Team, for outstanding management, incorporating lessons-learned, and overcoming unforeseen challenges in the production of the Exploration Mission-1 crew module pressure vessel. The Agency Honor Awards are approved by NASA Administrator Charles Bolden and presented to selected individuals and groups, both government and non-government, who have distinguished themselves by making outstanding contributions to the agency's mission.

(Left to right) NASA Administrator Charles Bolden, Paul Sannes, NASA Deputy Administrator Dava Newman.

WOW! HOUSTON'S SUPER BOWL LIVE TO BE OUT OF THIS WORLD!

Images courtesy Houston Super Bowl Host Committee

Mark Mulqueen, Boeing; Todd Probert, Raytheon, Wanda Sigur, Lockheed Martin; Ellen Ochoa, NASA; Sallie Sargent, Houston Super Bowl Host Committee; Robert Koch, Raytheon; Julie Van Kleeck, Aerojet Rocketdyne; Mary Lynne Dittmar, Coalition for Deep Space Exploration; Brian Duffy, Orbital ATK.

As Houston prepares to host the Super Bowl, NASA and leading aerospace industry companies have teamed up with the Houston Super Bowl Host Committee to showcase space exploration as part of Houston's identity. Houstonians, visitors and Super Bowl LI fans will be able to enjoy a one-of-a-kind, interactive experience for 10 days leading up to the big game in Houston on Feb. 5, 2017.

NASA, Aerojet Rocketdyne, Boeing, Lockheed Martin Corporation, Northrop Grumman Corporation, Orbital ATK and Raytheon Company are working together to share the exciting story of America's current efforts in the development of new rockets, engines, crew capsules, astronaut training programs and deep space science that will reveal valuable discoveries and transport humans to other planets.

On Nov. 16, the Houston Super Bowl Host Committee unveiled *Future Flight* as its "WOW" Factor for the 2017 Super Bowl LIVE fan festival. Featuring an out-of-this world virtual reality experience and numerous hands-on space exhibits, *Future Flight* will share with the public the incredible journey to Mars and beyond. The unveiling took place at the 2016 Space Commerce Conference and Exposition (SpaceCom) held at the George R. Brown Convention Center in Houston.

Future Flight's key component is a virtual reality ride that takes guests on an excursion through space to the Red Planet and back, using actual footage from Mars. Guests don virtual reality goggles for the 2-minute, 10-second ride. It concludes with a 90-foot drop that transports the rider visually from Mars back to Earth, landing on the 50-yard-line of NRG Stadium, just in time for kickoff of Super Bowl LI. For guests who prefer not to experience the 90-foot drop, there will be a special presentation area outside of the attraction to experience the virtual reality portion of *Future Flight*.

In addition, Orion and Space Launch System team members will join their planetary exploration experts to talk with the public and answer questions about deep space exploration beyond the moon and throughout our solar system. The full-scale Orion Post-Landing Recovery Test (PORT) mockup will be on display and Lockheed Martin will feature its Generation Beyond Mars Experience Bus, which is the first immersive virtual reality vehicle ever built. The bus takes riders across a Martian landscape to experience a virtual drive along the surface of the Red Planet.

To preview the Mars Experience Bus:
lockheedmartin.com/generationbeyond/mars-experience

Super Bowl LIVE and Future Flight will be open to the public from Jan. 28, 2017 through Feb. 5, 2017. The 10-day fan festival, held the week of Super Bowl LI, will be a free event in and around Discovery Green in downtown Houston, and will feature music, games and attractions.

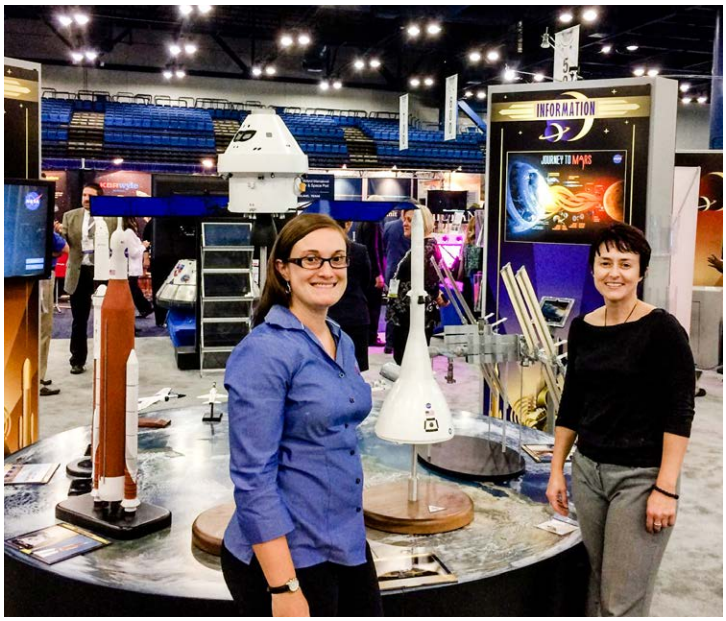
For more information, visit **www.housuperbowl.com** or follow the Host Committee on Twitter **@HouSuperBowl**.

ORION AT SPACECOM IN HOUSTON

Orion and SLS NASA and industry team representatives participated in the 2nd annual SpaceCom Expo held Nov. 15-17 in Houston. Launched in 2015, SpaceCom is a three-day event engineered to fuel business innovation across the aerospace, medical, energy, maritime, agribusiness, and advanced manufacturing industries.

Industry team partners participated in "The Making of a Mars Mission" panel presentation on our current progress toward deep space exploration on Nov. 16 as NASA and Lockheed Martin team members supported the NASA exhibit at the event throughout the week.

Read the *Houston Chronicle* article: **bit.ly/2hPyTVT**



Kat Coderre and Lora Lechago with Lockheed Martin at the NASA exhibit.

(Page Top) Karrie Abelein, Lockheed Martin; Orion/SLS Supplier John Couch of Futuramic; Tim Kokan, Ph.D., Aerojet Rocketdyne; NASA Astronaut Jessica Meir; and Darby Cooper, Boeing, following their panel presentation.

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

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DECEMBER

OMS Engine Ships to Germany

Crew Module Adapter in Clean Room

Orion Team Visits Houston Suppliers