



KENNEDY SPACE CENTER'S

# SPACEPORT

m a g a z i n e

## OSIRIS-REx PREP

Spacecraft ready for seven-year journey



# KENNEDY SPACE CENTER'S SPACEPORT MAGAZINE CONTENTS

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**Cover:** Team members guide a solid rocket motor into position for attachment to the United Launch Alliance Atlas V rocket first stage booster at Space Launch Complex 41 on Florida’s Cape Canaveral Air Force Station. With a Centaur upper stage, the rocket will boost NASA’s Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer, or OSIRIS-REx spacecraft. Targeted for liftoff Sept. 8, 2016, OSIRIS-Rex will be the first U.S. mission to sample an asteroid, retrieve at least two ounces of surface material and return it to Earth for study. The asteroid, Bennu, may hold clues to the origin of the solar system and the source of water and organic molecules found on Earth. Photo credit: NASA/Kim Shiflett

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## NASA'S LAUNCH SCHEDULE

**Date:** Sept. 6, 9:14 p.m. EDT  
**Mission:** Expedition 48 Crew Landing  
**Description:** NASA astronaut Jeff Williams and cosmonauts Alexey Ovchinin and Oleg Skripochka of Roscosmos will undock their TMA-20M Soyuz spacecraft from the Poisk module of the International Space Station and return to Earth, landing in Kazakhstan.  
<http://go.nasa.gov/2a4GLAi>

**Date:** Sept. 8, 7:05 p.m. EDT  
**Mission:** OSIRIS-REx  
**Description:** The mission will study Bennu, a near-Earth asteroid that is about one-third of a mile across. OSIRIS-REx will bring a small sample back to Earth for study. As planned, the spacecraft will reach its asteroid target in 2018 and return a sample to Earth in 2023.  
<http://go.nasa.gov/1ItsRkl>

**Targeted Date:** September  
**Mission:** Orbital ATK Resupply Mission to Space Station (Orbital CRS-5)  
**Description:** Orbital ATK’s Cygnus cargo delivery to the International Space Station is targeted for a mid September launch on the Antares rocket from the Mid-Atlantic Regional Spaceport’s Pad OA at NASA Wallops Flight Facility in Virginia.

**Date:** Sept. 23, 2:17 p.m. EDT  
**Mission:** Expedition 49 Launch  
**Description:** NASA astronaut Shane Kimbrough and cosmonauts Andrey Borisenko and Sergey Ryzhikov of the Russian space agency Roscosmos will launch to the space station Sept. 23 aboard the Soyuz MS-02 spacecraft from the Baikonur Cosmodrome in Kazakhstan.  
<http://go.nasa.gov/2as0WLv>

National Aeronautics and Space Administration



## JIM CAWLEY

“Here is a fun fact for you . . .”

Over the years, I can’t count the number of times my son started a sentence with those words. And much of the time, these “fun facts” have been about space.

I support BA as the Kennedy Space Center awards writer, reviewing and editing employee award nominations with the goal of getting as many approved as possible. I take great pride in helping our employees receive well-earned recognition for their exceptional accomplishments. I also am in charge of HR Insights, BA’s monthly newsletter.

My passion for writing comes from a journalism background; my passion for space comes from living and working on the Space Coast — and, of course, from my son. My family and I moved to Brevard from Connecticut in 2004. A 10-year stint as a reporter and copy editor at Florida Today kept me close to the happenings at Kennedy.

On a recent trip to Ireland, I overheard a man talking about launches and reusable rockets. I looked at my wife in amazement as I heard the words “Kennedy Space Center” uttered in a thick, Irish brogue. Here I was 4,000 miles away, and the topic of conversation was my place of work!

As my son begins his freshman year of college and I head into my second year at the center, we still discuss “fun facts” about space. But now, many of these come from me.





# ORIGINS OF LIFE

## OSIRIS-Rex prepped for mapping, sampling mission to Bennu

BY LINDA HERRIDGE

Technology



NASA's OSIRIS-Rex spacecraft rotates on a spin table during a weight and center of gravity test May 24 inside the Payload Hazardous Servicing Facility at Kennedy Space Center. The spacecraft is being prepared for its upcoming launch, targeted for Sept. 8 aboard a United Launch Alliance Atlas V rocket. Photo credit: NASA/Kim Shiflett

The first U.S. mission to travel to an asteroid, retrieve samples and return them to Earth is being prepared for a Sept. 8 launch atop a United Launch Alliance Atlas V rocket from Cape Canaveral Air Force Station in Florida. This groundbreaking mission, several years in the making, is the Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer, also known as OSIRIS-Rex. It will travel to near-Earth asteroid Bennu, map its surface using 3-D laser imaging, retrieve samples from the surface and return to Earth.

"The OSIRIS-Rex mission is a seven-year journey from launch to Earth return," said Dante Lauretta, principal investigator. He is a professor at the Lunar and Planetary Laboratory at the University of Arizona.

The spacecraft will spend the first two years of the mission cruising to asteroid Bennu, arriving in August 2018. The five specialized instruments on OSIRIS-Rex will be used to map the asteroid's surface, identify the minerals and chemicals that may be on the surface, and select the sample site.

"The primary objective of the mission is to bring back 60 grams of pristine carbon-rich material from the surface of Bennu," Lauretta said. "We expect these samples will contain organic molecules from the early solar system that may give us information and clues to the origin of life."

In July 2020, the spacecraft will briefly touch the surface of the asteroid to collect loose rocks and dust using its Touch-and-Go Sample Acquisition Mechanism, or "TAGSAM," and store the material in a sample return capsule. The spacecraft will depart the asteroid in March 2021, when the departure window opens, and travel for two-and-a-half years on a trajectory for Earth return in September 2023.

As OSIRIS-Rex approaches the Earth, the sample return capsule will eject from the spacecraft and land with the help of parachutes at the Utah Test and Training Range, southwest of Salt Lake City. The canister will be retrieved and transported to NASA's Johnson Space Center in Houston for analysis. The main OSIRIS-Rex spacecraft will remain in orbit around the Sun after the sample return and



Technicians and engineers cycle the sample return capsule door July 13 in a test of NASA's OSIRIS-Rex spacecraft inside the Payload Hazardous Servicing Facility at Kennedy Space Center. Photo credit: NASA/Kim Shiflett

Earth flyby. The mission will lay the groundwork for future exploration of asteroids and other small bodies in the solar system.

Prior to launch, the appropriate steps are being taken to assure mission success.

OSIRIS-Rex arrived at Kennedy Space Center on May 20 and was transported to the Payload Hazardous Servicing Facility, or PHSF, the same day. Inside the PHSF it was processed and prepared by the spacecraft team for its mission.

Technicians and engineers performed illumination tests on the spacecraft solar arrays, tested instrument hardware and communication systems, performed a weight and center of gravity test and installed thermal blankets around the spacecraft to protect it from the extreme temperatures of space. Propellant also was loaded into the spacecraft that will help it to reach Bennu and return to Earth.

"We processed this payload in a very clean environment," said Rex Engelhardt, Launch Services Program mission manager for OSIRIS-Rex. "We don't want to contaminate the samples that OSIRIS-Rex will return to us."

In the PHSF, the processing team placed sample plates near OSIRIS-Rex to collect contamination samples. These samples will be compared with the samples that are returned from the asteroid in order to eliminate any contamination that may have occurred in the

PHSF.

OSIRIS-Rex was placed in its payload fairing Aug. 19, and transported to the Vertical Integration Facility at Space Launch Complex 41 for lifting and mating to the rocket Aug. 30.

"The asteroid Bennu is about 1,600 feet (492 meters) in diameter. Think of it as a small mountain in space," Lauretta said. "It is a near-Earth asteroid that makes occasional close approaches to our planet."

Lauretta said he is honored to lead a program like OSIRIS-Rex for NASA and the country.

"The team is an amazing group of very talented, dedicated people who are excited about the program and really believe in the mission. I couldn't be more proud of their accomplishments, and the launch is the culmination of years and years of hard work," Lauretta said.

OSIRIS-Rex is the third mission in the agency's New Frontiers Program. NASA's Goddard Space Flight Center in Greenbelt, Maryland, is providing overall mission management, systems engineering, and safety and mission assurance for the spacecraft. Lockheed Martin Space Systems in Denver built the spacecraft. NASA's Marshall Space Flight Center in Huntsville, Alabama, manages New Frontiers for the agency's Science Mission Directorate in Washington.



# NASA awards launch services contract for Mars 2020 rover mission

SPACEPORT MAGAZINE REPORT

**N**ASA has selected United Launch Services LLC of Centennial, Colorado, to provide launch services for a mission that will address high-priority science goals for the agency's Journey to Mars.

Mars 2020 is targeted for launch in July 2020 aboard an Atlas V 541 rocket from Space Launch Complex 41 at Cape Canaveral Air Force Station in Florida. The rover will conduct geological assessments of its landing site on Mars, determine the habitability of the environment, search for signs of ancient Martian life, and assess natural resources and hazards for future human explorers.

Additionally, scientists will use the instruments aboard the rover to identify and collect samples of rock and soil, encase them in sealed tubes, and leave them on the surface of Mars for potential return to Earth by a future mission to the Red Planet.

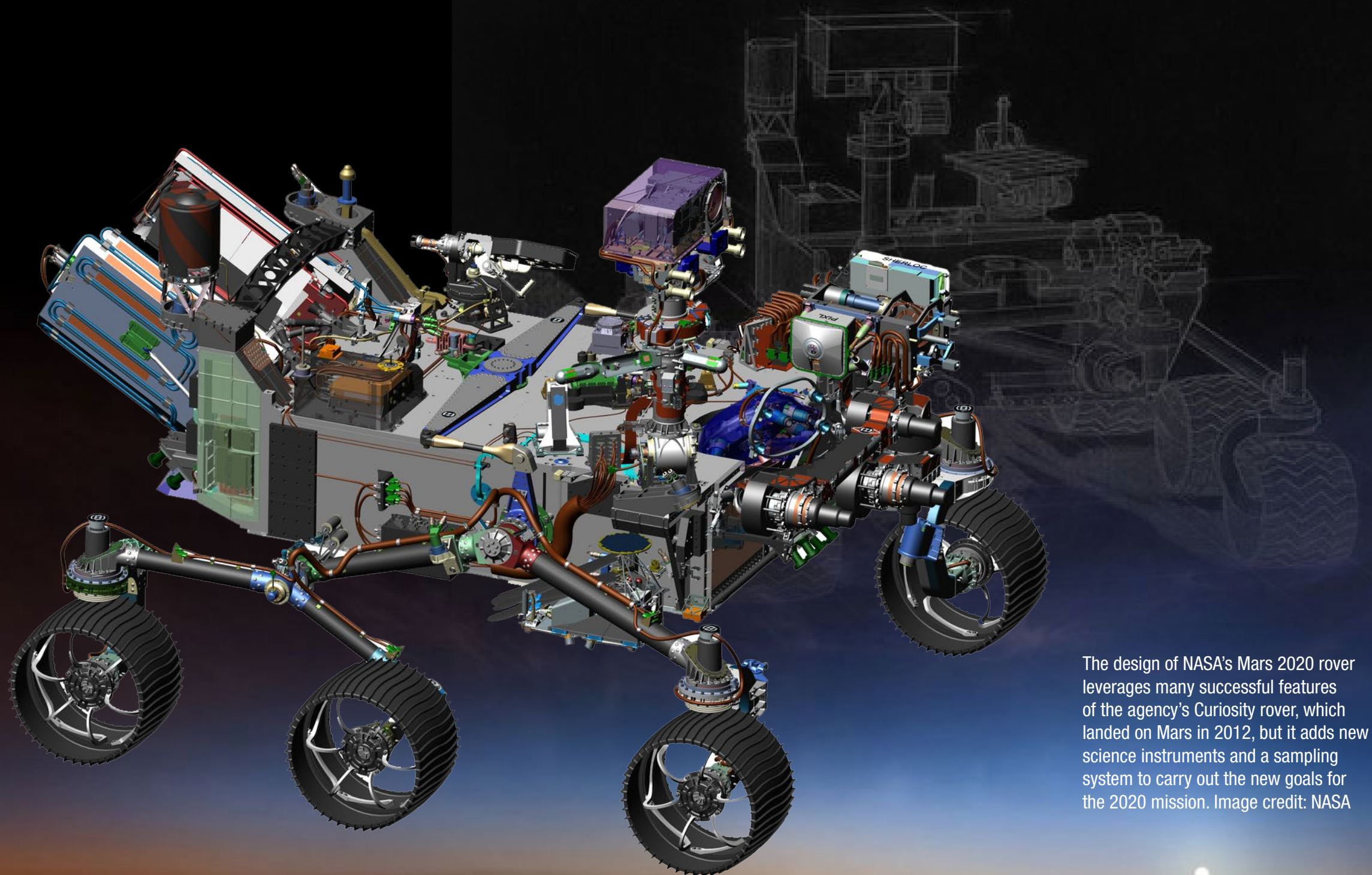
The mission will build on the achievements of Curiosity and other Mars Exploration Program missions, and offer opportunities to deploy new capabilities developed through investments by NASA's Space Technology Program and Human Exploration and Operations Mission Directorate, as well as contributions from international partners.

The Mars 2020 rover mission presents new opportunities to learn how future human explorers could use natural resources available on the surface of the Red Planet. An ability to live off the land could reduce costs and engineering challenges posed by Mars exploration.

The total cost for NASA to launch Mars 2020 is about \$243 million, which includes: the launch service; spacecraft and spacecraft power source processing; planetary protection processing; launch vehicle integration; and tracking, data and telemetry support.

NASA is on an ambitious journey to Mars that includes sending humans to the Red Planet. The robotic missions of NASA's Planetary Science Division are leading the way with the upcoming Mars 2020 rover, the InSight lander mission targeted for 2018, Opportunity and Curiosity rovers currently exploring the Martian surface, Odyssey and Mars Reconnaissance Orbiter spacecraft currently orbiting the planet, and the Mars Atmosphere and Volatile Evolution Mission (MAVEN) orbiter, which is helping scientists understand what happened to the planet's atmosphere.

NASA's Launch Services Program at Kennedy Space Center will manage and oversee the Atlas V launch service for Mars 2020. The Mars 2020 Project at NASA's Jet Propulsion Laboratory in Pasadena, California, manages the Mars 2020 spacecraft development for the Science Mission Directorate at NASA Headquarters in Washington.



The design of NASA's Mars 2020 rover leverages many successful features of the agency's Curiosity rover, which landed on Mars in 2012, but it adds new science instruments and a sampling system to carry out the new goals for the 2020 mission. Image credit: NASA

For more information about NASA's Mars 2020 rover, visit:  
<http://mars.nasa.gov/mars2020/>

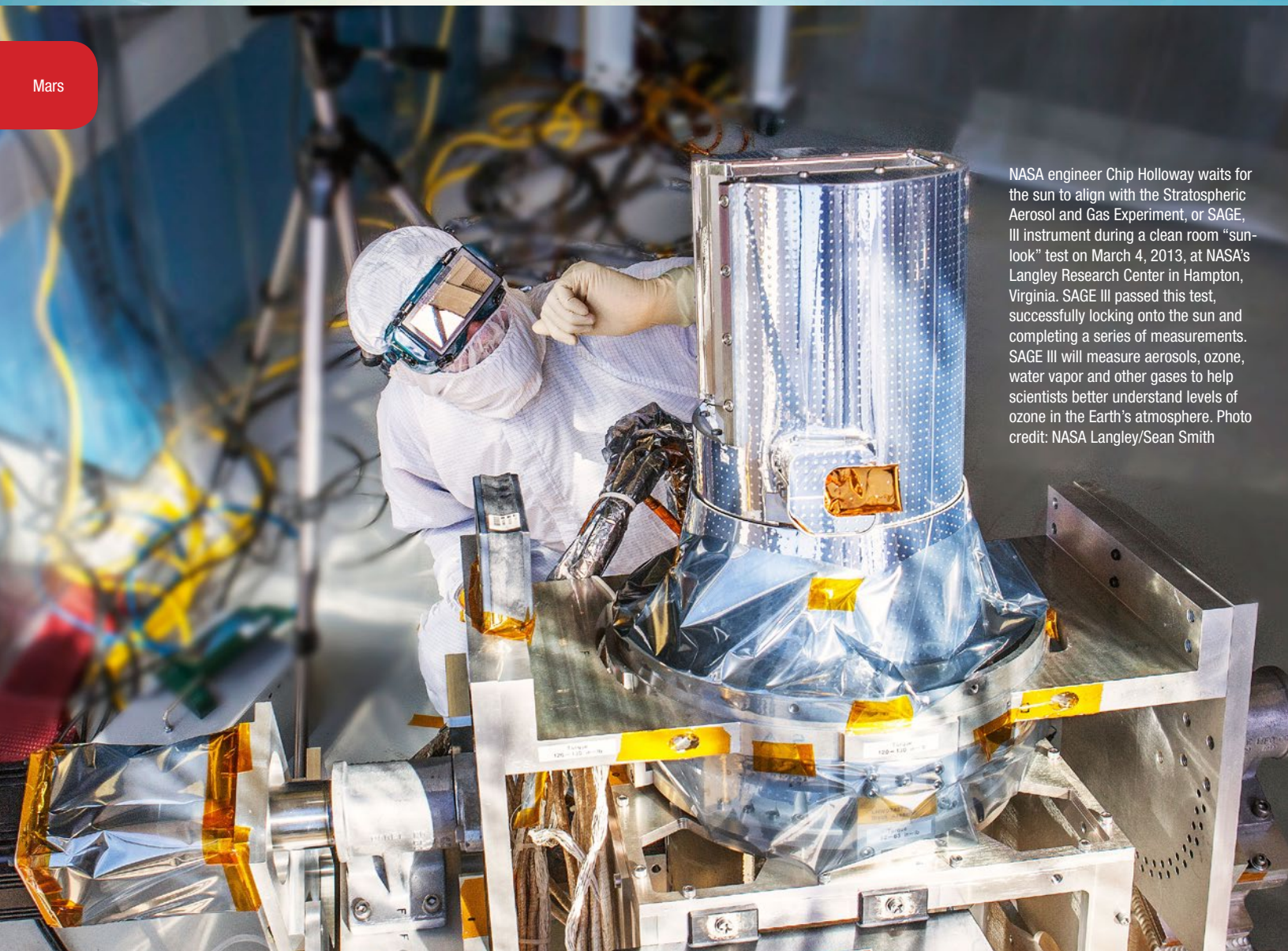
For more information about NASA's Launch Services Program, visit:  
<http://www.nasa.gov/launchservices>



# 'Zone Defense

## SAGE III to look back at Earth's atmospheric 'sunscreen'

BY BOB GRANATH



NASA engineer Chip Holloway waits for the sun to align with the Stratospheric Aerosol and Gas Experiment, or SAGE, III instrument during a clean room "sun-look" test on March 4, 2013, at NASA's Langley Research Center in Hampton, Virginia. SAGE III passed this test, successfully locking onto the sun and completing a series of measurements. SAGE III will measure aerosols, ozone, water vapor and other gases to help scientists better understand levels of ozone in the Earth's atmosphere. Photo credit: NASA Langley/Sean Smith

On the upcoming SpaceX CRS-10 resupply mission to the International Space Station (ISS), a Dragon spacecraft will deliver the Stratospheric Aerosol and Gas Experiment (SAGE) III instrument to further study ozone in the atmosphere.

Once mounted on the space station, SAGE III will measure the Earth's sunscreen, or ozone, along with other gases and aerosols, or tiny particles in the atmosphere. SAGE will make its measurements by locking onto the sun or moon and scanning the limb, or thin profile of the atmosphere from that unique vantage point.

During the late 1970s, scientists began tracking a steady decline

of ozone in the Earth's stratosphere. It was determined this was caused by extensive use of human-produced chemicals. Following years of global efforts to significantly reduce the number of ozone-depleting substances, experts now are optimistic the ozone layer will recover.

Launch atop a SpaceX Falcon 9 rocket currently is scheduled for late fall this year.

NASA has a team of specialists with decades of experience dedicated to Earth science research such as SAGE III.

The fourth generation in a series of NASA Earth-observing

instruments, SAGE III will be mounted on the space station where it will use the unique vantage point of low-Earth orbit to make long-term measurements of ozone, aerosols, water vapor and other gases in Earth's atmosphere.

### Preparing for Launch

Since the instrument arrived Kennedy Space Center, engineers at the Florida spaceport have assisted SAGE team members from NASA's Langley Research Center in Hampton, Virginia in preparing it for launch.

According to Rob Kuczejda, a Kennedy project manager in the ISS Utilization and Life Sciences Office, this SAGE III effort has been underway for several years.

"Our role actually began back in September 2011," he said. "We sent a small delegation of engineers to Langley to meet with the SAGE team and learn about the payload. Our message was that Kennedy had years of expertise processing ISS payloads and that we were available to assist with SAGE III. Over the next four years, Kennedy engineers helped assemble and test parts of the payload."

SAGE III now is being stored in the high bay of Kennedy's Space Station Processing Facility (SSPF), a world-class processing laboratory. Every American-launched element for construction of the ISS, all cargo and each experiment is prepared and checked out in the SSPF, a crucial part of a premier multi-user spaceport.

While space station construction is complete, the facility remains active where specialized ISS payloads continue to be processed and tested prior to launch.

Because of the instrument's special optics, additional precautions during testing and processing were necessary.

"We spent about a year designing and constructing a super-clean 'tent' in the SSPF high bay," Kuczejda said. "This is considered a Class '10K,' or 10,000, clean room. The designation signifies that there are less than 10,000 particles greater than half-micron in size in any cubic foot of air — that's about 150 times cleaner than the air in the average living room."

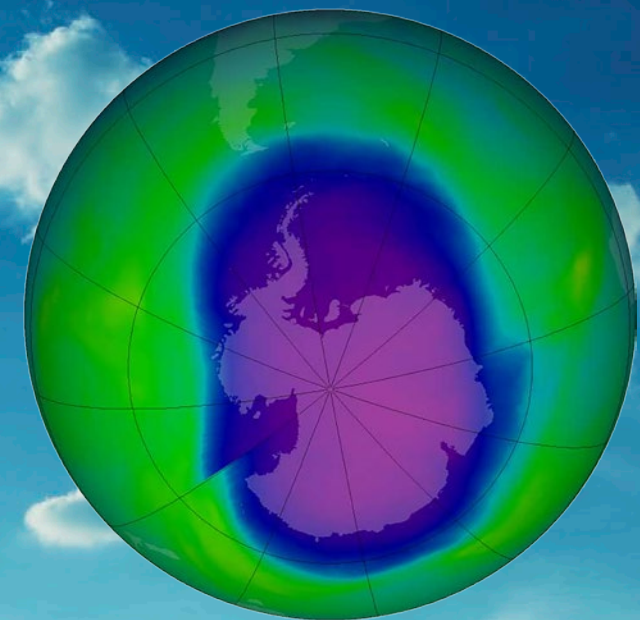
The special care and testing will ensure SAGE III is ready for its crucial role of studying the Earth.

### The Ozone Hole

The highest levels of ozone in the atmosphere are in the stratosphere, a region also known as the ozone layer from about 6 to 31 miles above the Earth's surface. Ozone depletion has included larger springtime decreases in stratospheric ozone around Earth's polar regions, often referred to as the "ozone hole."

"When scientists realized there was a hole in the ozone layer," Kuczejda said, "it was determined that man-made chemicals were rapidly depleting ozone in the parts of the atmosphere that protect us from the harmful UV (ultraviolet) rays of the sun."

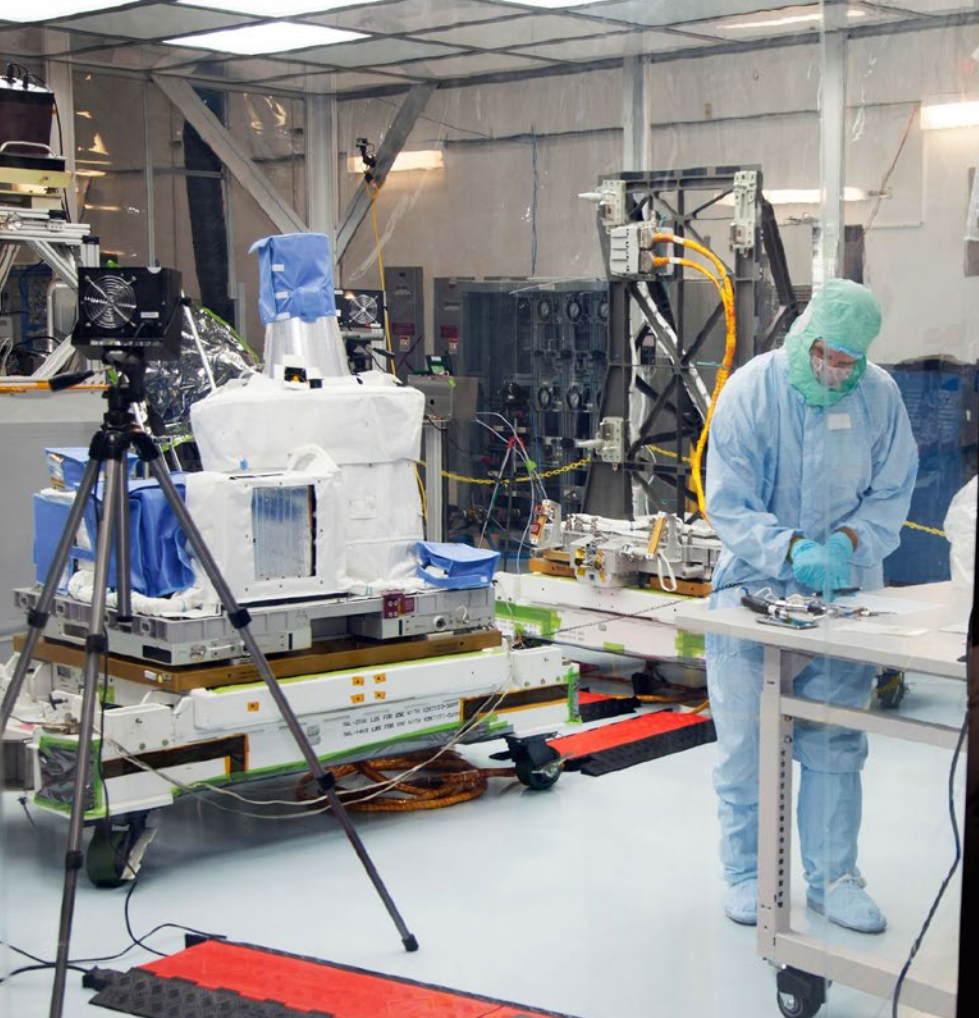
After the discovery, worldwide concern grew because the unabsorbed portion of UV rays passing through the ozone layer causes sunburns in humans, as well as direct DNA damage in living tissues in both plants and animals.



NASA's Aura satellite observed the most severe ozone hole over Antarctica in 2006. The severity of the ozone hole resulted from the high ozone-depleting substance levels and the record cold conditions in the stratosphere over the South Pole. Aura is dedicated to understanding the changing chemistry of Earth's atmosphere.

Photo credit: NASA





Operations are underway to close out processing of NASA's Stratospheric Aerosol and Gas Experiment III, or SAGE III, instrument in the Space Station Processing Facility at Kennedy Space Center. On May 16, an engineer is working in a super-clean 'tent' built in the SSPF high bay to protect SAGE III's special optics. The class '10K,' or 10,000, clean room provides an environment in which there is less than 10,000 particles of less than a half micron inside. That's about 150 times cleaner than the air in the average living room. Photo credit: NASA/Charles Babir

***"It will be good to know that the efforts we are taking here, with the science community and across the globe, are actually improving and getting the ozone layer back to where it was 60 years ago."***

– Randy Wade

Support Manager in Kennedy's  
Exploration Research and Technology  
Programs Directorate

Scientists determined the primary cause of ozone depletion was extensive use of chlorofluorocarbons employed as refrigerants, solvents and propellants in aerosol sprays.

To better understand this phenomena, SAGE was first flown during 1979 as a follow-up to the Stratospheric Aerosol Measurement, or SAM, on the July 1975 Apollo-Soyuz mission. SAGE II was a part of the Earth Radiation Budget Satellite, or ERBS, deployed by the crew of space shuttle Challenger in 1984. The SAGE III designed for the ISS is almost a duplicate of one launched in 2001 on a Russian Meteor-3M satellite.

On Sept. 16, 1987, an international treaty, known as the Montreal Protocol, was signed by most nations of the world.

The agreement called for phasing out production of many of the substances that were responsible for ozone depletion. The treaty has been in force since Jan. 1, 1989.

The Intergovernmental Panel on Climate Change (IPCC), a scientific organization under the auspices of the United Nations, announced in 2005 that their observations of the stratosphere showed that the global amount of ozone is stabilizing. The IPCC study indicates that the atmosphere layer is expected to begin to recover in coming decades if the ban on ozone-depleting substances continues.

"It will be good to know that the efforts we are taking here, with the science community and across the globe, are actually improving and getting the ozone layer back to where it was 60 years ago," said Randy Wade, support manager of off-line labs in Kennedy's Exploration Research and Technology Programs Directorate.

### ***Testing and Teamwork***

To ensure SAGE III will be ready to go to work once it arrives at the ISS, extensive checkouts have been taking place in the special processing area of the SSPF.

"The processing has included functional testing on the payload, to verify everything is operating correctly after shipment of the



***"We spent about a year designing and constructing a super-clean 'tent' in the SSPF high bay . . . that's about 150 times cleaner than the air in the average living room."***

– Rob Kuczajda

Project Manager in Kennedy's  
ISS Utilization and Life Sciences Office

payload from Langley to Florida," Kuczajda said.

Jennifer Wahlberg, also a Kennedy utilization project manager, has played a key role in helping coordinate the Langley team's testing.

"We have been assisting the SAGE III team from Langley with our ISS simulators," she said. "They have performed command and data handling checkouts to make sure everything is going to transmit the data correctly, that commands go up and data can come down."

Wahlberg explains that most of the SAGE III checkouts have been completed for the time being.

"They have done as much as they can so far," she said. "About two months from launch, the SAGE III team from Langley will return to Kennedy for their final checkouts and tests."

Kuczajda pointed out that after the SAGE III team returns in September and hardware inspections are complete, the instrument will go back into the shipping container.

"The Kennedy Logistics team will deliver the instrument to the SpaceX payload processing facility at Cape Canaveral Air Force

Operations are underway May 16 to closeout processing of the agency's Stratospheric Aerosol and Gas Experiment III, or SAGE III, instrument. Since December 2015, engineers and technicians have prepared the device for its launch to the International Space Station later this year aboard a Dragon spacecraft launched atop a SpaceX Falcon 9 rocket. Photo credit: NASA/Charles Babir

Station where it will be prepared for flight aboard the Dragon spacecraft," he said.

Wahlberg had high praise for the team from Langley.

"It's been great to work with the SAGE III team for the past several years," she said. "It's really amazing to see how many people can work together to bring successful science to bear."

"And the feeling is mutual," said Mike Cisewski, SAGE III/ISS project manager at NASA's Langley Research Center. "Support from the KSC team has been exemplary through our payload development and processing at KSC. From logistics, to assembly of portions of our Nadir Viewing Platform and vibration testing fixture, for outstanding support at the Space Station Processing Facility, they have been great partners."

Once SAGE III is installed on the ISS, Wade is hoping the instrument sends back data that the ozone layer is improving.

"I've seen a lot of changes in fluorocarbon use," he said. "We've done a lot of things here at the Kennedy Space Center to reduce the use of fluorocarbons, and automobile cooling systems have changed. So they are going to try to verify if those efforts made on Earth have helped improve the ozone layer."

Wahlberg sees long-term benefits in the SAGE III research.

"I wish all the payload teams and the science teams great success," she said. "I know they are doing important work for our future generations."



# I Will LAUNCH AMERICA

*Restoring America's Human Launch Capability*



**Brittani Sims**  
Certification Systems Engineer  
NASA's Commercial Crew Program

## I Will Launch America: Certification Systems Engineer Brittani Sims

BY JOSHUA FINCH,

**B**rittani Sims is one of the many dedicated employees supporting NASA's Commercial Crew Program at Kennedy Space Center. An electrical engineer by education, Sims developed a passion for safety and human spaceflight in high school after watching the space shuttle on TV.

"I was just sitting on the couch watching TV and the news was covering the return of the space shuttle," said Sims. "I wasn't even aware what NASA did at the time. I remember asking my mom, 'Did you know that we put people into space?' When I went to school the next week, I told people that I wanted to work for NASA, and a lot of them didn't really believe me."

Sims says those doubts only served as additional motivation for her to achieve her goals.

"I knew that it would be a challenge for me to make it to NASA," Sims said. "At times, I even wondered if it would be possible, but I needed to prove to myself and my family that I could make it."

She first came to Kennedy as an intern after applying to a Science, Technology, Engineering and Mathematics, or STEM, program called NASA's MUST or Motivating Undergraduates in Science and Technology. The education program was designed to develop STEM expertise for groups that were underrepresented in the work force.

"I was able to do meaningful work as a junior in college with this program," Sims said. "I was hired full-time at the completion of my degree from Morgan State University. I had finally made it to NASA."

Sims came to Commercial Crew after working as surveillance project engineer for the space shuttle. She now works on the SpaceX certification team helping make the idea of commercial, human spaceflight a reality.

"My job is to support integration with our SpaceX partner," said Sims. She helps manage review milestones and tracks the partner's progress on their design updates to meet NASA requirements,

deliver certification products and complete safety assessments. "I collaborate with the systems offices to ensure requirements are met before we fly. This is exactly the kind of work I wanted to do when I set a goal of working for NASA."

Commercial Crew is enabling private companies, like Boeing and SpaceX, to carry people to low-Earth orbit destinations, including the International Space Station. Boeing is developing the CST-100 Starliner that will launch atop of a United Launch Alliance Atlas V, while SpaceX is developing its Crew Dragon to ride on its Falcon 9 rocket.

Sims says there's a wealth of knowledge in Commercial Crew from people who have a great deal of experience in spaceflight and getting to work side-by-side with them is both exciting and humbling.

"I am a part of a team with unique backgrounds that's working together to launch astronauts from U.S. soil," said Sims. "It's interesting to experience how we move from a piece of paper to seeing hardware actually built. We are taking our program's mission and making it into a reality."

Commercial Crew is breaking new ground for the future of human spaceflight, said Sims.

"It's awesome working on something this exciting," said Sims. "Everyone at NASA and with our providers is working relentlessly to get there."

Sims also sees Commercial Crew as an opportunity to inspire and drive a new generation to pursue a career in science and technology.

"This is an opportunity to inspire a little girl who's sitting on the couch watching television that she can do something great," Sims said. "My 3-year-old son tells me that he wants to go to space all the time. I think about the work that I am doing right now, and I believe that one day he will be able to climb on a commercial spacecraft and fly. This is the bigger picture of what NASA and our commercial partners are doing."



# Fired Up!

## Engine test shows design ready for new era

BY STEVEN SICELOFF

ISS



NASA astronauts Eric Boe, from left, Barry "Butch" Wilmore and Suni Williams listen as United Launch Alliance engineer Tom Harper discusses aspects of an RL10 engine during a tour of Aerojet Rocketdyne's facility in West Palm Beach, Florida. Photo credit: NASA/Dimitri Gerondidakis

A trio of NASA astronauts watched Friday as engineers and technicians from Aerojet Rocketdyne fired one of the RL10 engines that will help power the first crewed flight test of Boeing's CST-100 Starliner as it flies into orbit on a United Launch Alliance Atlas V rocket.

Steam billowed from the test stand in West Palm Beach, Florida, for about six minutes as the engine burned a combination of liquid hydrogen and liquid oxygen to produce some 22,300 pounds of thrust. Bolted into place inside a vacuum chamber, the engine was shut down and then re-ignited just as it will be when it is pushing a spacecraft into orbit.

"Today's test was just amazing and from what it looked like, it looked flawless," said astronaut Eric Boe, one of four NASA astronauts training to fly on the flight tests of the agency's Commercial Crew Program missions. "They'll pore through the data, but the cool part is that the next time that engine fires, it's going to put one of us in space and we're looking forward to it."

After verifying the test was good and the information complete, Aerojet Rocketdyne will ship the same engine tested Friday to ULA's Decatur, Alabama, plant where it will be bolted alongside an identical engine to the upper stage of an Atlas V booster for the crewed flight test. That stage, called Centaur, will take over once

the first stage is spent and falls away during the climb into space. The Centaur will push the Starliner with astronauts inside to orbital velocity and put it on course to the International Space Station.

The engines for the first Starliner flight test – which will be flown without a crew aboard – have already been through acceptance testing including a similar engine firing and are now in different stages of processing at Aerojet Rocketdyne and ULA. Engines for future crew rotation missions to the station also are in various stages of production.

***"They'll pore through the data, but the cool part is that the next time that engine fires, it's going to put one of us in space and we're looking forward to it."***

– Eric Boe  
Commercial Crew Astronaut

Although RL10s have been in use for more than 50 years and propelled NASA probes to distant worlds including the New

Horizons spacecraft that surveyed Pluto for the first time last year, the engines have not been used on flights carrying people.

"The last and most important thing for the RL-10s to do is put people into space," said Matthew Bullivant, lead engineer for RL-10 integration for Aerojet Rocketdyne.

RL10 engines also are slated for use on the Space Launch System rocket in development to lift astronauts to deep-space destinations aboard Orion spacecraft. A single RL10 will power the Interim Cryogenic Propulsion Stage during the first test flight of SLS and Orion, known as Exploration Mission-1, targeted for launch without a crew in 2018. Four RL10s will be on the more powerful Exploration Upper Stage for SLS that could be used as early as the first crewed flight of SLS and Orion, known as Exploration Mission-2, and targeted for launch in 2021.

"My first impression was that everything was by the book and the team showed great attention to detail, which is what you have to do in this business otherwise bad things happen," said astronaut Barry "Butch" Wilmore. "Confidence comes in many ways, it's meeting the people, it's seeing the tests and there's a lot of trust in a lot of the things we do."

The test was a standard firing all engines go through before they are counted on to power a mission in flight. As the engine burned on the test stand, the teams watched from a control room a safe distance away, controlling the event remotely.

With four cameras transmitting from inside the vacuum



NASA astronauts Barry "Butch" Wilmore, from left, Eric Boe and Suni Williams survey an RL10 engine as it stands in a vacuum chamber at Aerojet Rocketdyne's test stand in West Palm Beach, Florida. Photo credit: NASA/Dimitri Gerondidakis





NASA astronaut Eric Boe watches as Aerojet Rocketdyne test team engineers direct the test-firing of an RL10 engine at the company's facility in West Palm Beach, Florida. Photo credit: NASA/Dimitri Gerondidakis

chamber where the rocket engine fired, the astronauts and test team watched icicles form on the rim of the nozzle even as the fiery hot gas exited less than an inch away. Frost even formed on the walls of the engine because of the super-cold hydrogen and oxygen propellants coursing through the engine's turbopumps and

for partners of NASA's Commercial Crew Program. In Boeing's development with ULA of the Starliner and Atlas V for human-rated spaceflight to the International Space Station, Boeing has rebuilt a former space shuttle processing facility into a factory for Starliners while ULA has added a Crew Access Tower to Space Launch Complex 41 so astronauts can get access to the spacecraft as it stands pointed to the sky on launch day.

Also in partnership with the Commercial Crew Program, SpaceX is developing its Crew Dragon spacecraft and Falcon 9 rocket to take astronauts to the station. Both companies are tailoring their spacecraft and launchers for missions to the space station. The new spaceflight capability will give the station the ability to support a resident crew of seven, meaning astronauts aboard the orbiting laboratory will have twice as much time to perform critical research on long-duration missions.

The engine firing capped a visit by the astronauts in which they saw the engine assembly work underway, toured company facilities and met the work force.

"When you go through the whole process, seeing the test and seeing the professionals out here building the engines, there was no doubt the test would be a success," said Suni Williams, who is also training for Commercial Crew Program flight tests.

Engineers detailed specific elements of engine construction and showed the complex machinery involved with the work.

"This is what makes America great, and that's why it's so good to get out here and see things like this," Boe said.

***"When you go through the whole process, seeing the test and seeing the professionals out here building the engines, there was no doubt the test would be a success."***

– Suni Williams  
Commercial Crew Astronaut

plumbing. Frost doesn't form on the engines in space since there is no moisture available like there is in Florida.

"You actually put it through more hoops than it probably will see in a launch, so you know that it will handle anything that happens on the way to space," Boe said.

The engine test was the latest in a string of accomplishments

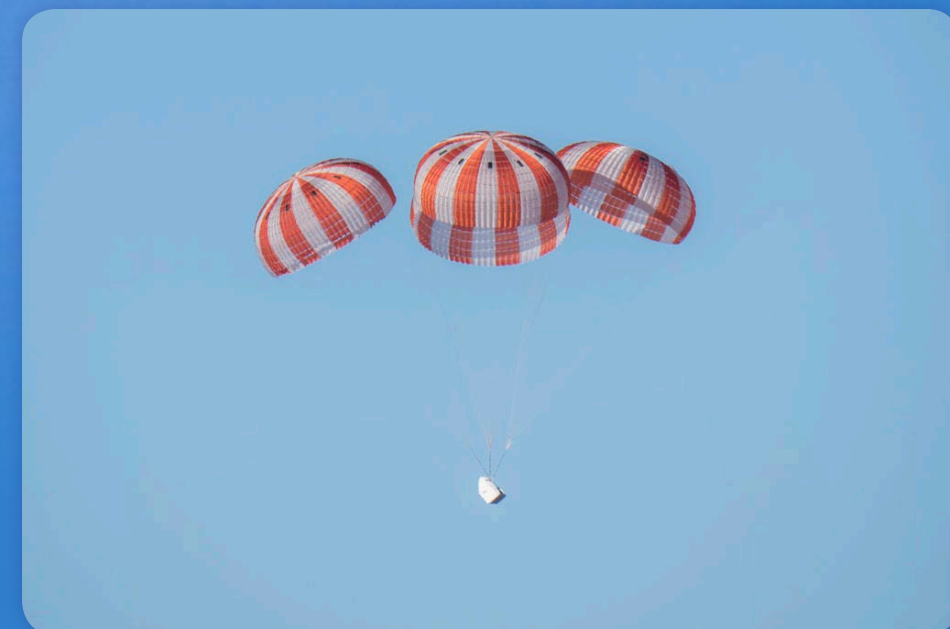
# SpaceX conducts successful Crew Dragon parachute system test



A Crew Dragon test article successfully deployed its four main parachutes as planned during a test that saw the SpaceX-made test article dropped from a C-130 aircraft 26,000 feet above Delamar Dry Lake, Nevada. The Crew Dragon, designed to fly astronauts to the International Space Station, will use four parachutes when returning to Earth. SpaceX plans to land the initial flight tests and missions in the Atlantic Ocean. SpaceX is working on a propulsive landing system the company intends to use in the future missions to propulsively land on land using its SuperDraco engines.

The parachute test is just one of an evaluation regimen that is expected to include many additional parachute drops of increasing complexity. SpaceX and NASA engineers will use the results throughout the test program to confirm the system and get it certified for use first on flight tests and then for operational missions. Photos courtesy of SpaceX.

**For more about NASA's Commercial Crew Program, go to <http://www.nasa.gov/commercialcrew>**



ISS



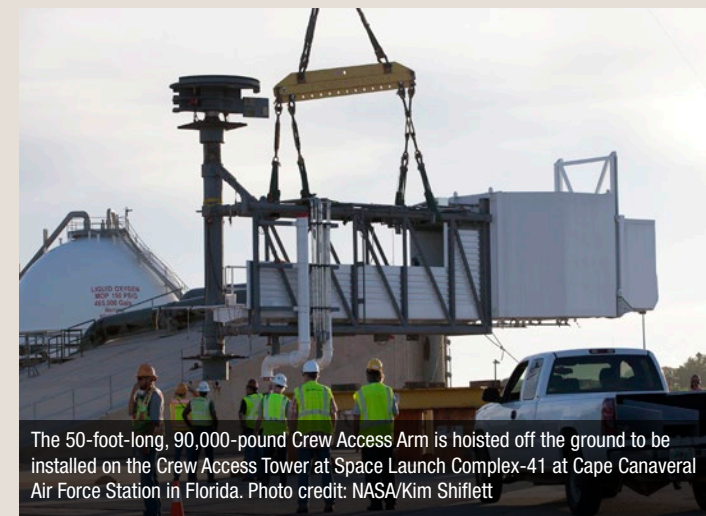
## Crew access arm installed for Starliner missions

BY STEVEN SICELOFF

The Crew Access Arm is in its retracted position on the Crew Access Tower to complete the lift and install operation. Photo credit: NASA/Kim Shiflett

The Crew Access Arm for a new generation of spacecraft was lifted into place Aug. 15 at Space Launch Complex-41 where workers are modifying the launch pad to give astronauts access to Boeing's CST-100 Starliner on launch day.

The 50-foot-long, 90,000-pound arm will form a bridge between the newly built Crew Access Tower and the hatch of the spacecraft. Astronauts will walk across the arm to climb inside the Starliner for flight. Poised to begin a mission, the Starliner will sit on top of a United Launch Alliance Atlas V rocket.



The 50-foot-long, 90,000-pound Crew Access Arm is hoisted off the ground to be installed on the Crew Access Tower at Space Launch Complex-41 at Cape Canaveral Air Force Station in Florida. Photo credit: NASA/Kim Shiflett

The arm also holds the White Room, an enclosed area big enough for astronauts to make final adjustments to their suits before climbing aboard the spacecraft.

Work began around 7:30 a.m. with crews attaching cables to the arm before a crane slowly hoisted it off the launch pad surface. Another crew of workers was waiting in the tower about 160 feet above the surface as the crane maneuvered one end of the arm into a notch on the tower. They bolted and welded the apparatus to the tower to complete the process.

***"You have to stop and celebrate these moments in the craziness of all the things we do."***

**—Kathy Lueders**

Manager of NASA's Commercial Crew Program

The addition of the arm is the latest in a rapid string of accomplishments for NASA's Commercial Crew Program and its partners. Working independently on separate contracts with NASA's program, Boeing and SpaceX are developing spacecraft and launch systems to take astronauts to the International Space Station. The additional launch capability will allow the resident crew of the station to grow by one, effectively doubling the time astronauts have in orbit to conduct science vital to spaceflight research, as well as investigations into benefits for those on Earth.

"You have to stop and celebrate these moments in the craziness of all the things we do," said Kathy Lueders, manager of NASA's

Commercial Crew Program. "It's going to be so cool when our astronauts are walking out across this access arm to get on the spacecraft and go to the space station."

The arm and tower have been constructed between Atlas V launches at SLC-41. The arm was built at a construction yard near Kennedy Space Center and trucked to the launch pad on Aug. 11. The tower was built in segments close to the launch pad and stacked together to form the nearly 200-foot-tall structure. It is the first new crew access structure at the Florida spaceport since the space shuttle's Fixed Service Structures were put in place before Columbia's first flight in 1981. It also is the first new crew access tower at Cape Canaveral Air Force Station since the Apollo Program.

"You think about when we started building this 18 months ago and now it's one of the most visible changes to the Cape's horizon since the 1960s," said Chris Ferguson, a former shuttle commander who is now Boeing's deputy program manager for the company's Commercial Crew Program. "It's a fantastic day."

The advances reminded some of the early days of human spaceflight when the first generation Atlas rockets put astronauts into orbit.

"John Glenn was the first to fly on an Atlas, now our next leap into the future will be to have astronauts launch from here on Atlas V," said Barb Egan, program manager for Commercial Crew for ULA.

Earth is not the only place work is underway to prepare for Commercial Crew missions. Astronauts on the International Space Station will perform a spacewalk Friday to install an International Docking Adapter to a station port that will allow visiting spacecraft including those on commercial crew missions to dock with the orbiting laboratory. Carried into orbit during the most recent cargo resupply mission, the IDA will become a doorway for astronauts as they cross from their spacecraft into the station. The adapters are outfitted with a network of sensors and fixtures that work with automated systems to dock the spacecraft to the port.



A crane lifts the Crew Access Arm and White Room for Boeing's CST-100 Starliner spacecraft to be attached to the Crew Access Tower at Cape Canaveral Air Force Station's Space Launch Complex 41 on Aug. 15. Photo credit: NASA/Kim Shiflett



# IN ROTATION

## NASA orders second SpaceX Crew Mission to International Space Station

BY STEPHANIE MARTIN

NASA took another important step Friday in returning U.S. astronaut launches from U.S. soil with the order of a second post-certification mission from commercial provider SpaceX in Hawthorne, California. Commercial crew flights from Florida's Space Coast to the International Space Station will restore America's human spaceflight launch capability and increase the time U.S. crews can dedicate to scientific research, which is helping prepare astronauts for deep space missions, including the Journey to Mars.

"The order of a second crew rotation mission from SpaceX, paired with the two ordered from Boeing will help ensure reliable access to the station on American spacecraft and rockets," said Kathy Lueders, manager of NASA's Commercial Crew Program. "These systems will ensure reliable U.S. crew rotation services to the station, and will serve as a lifeboat for the space station for up to seven months."

This is the fourth and final guaranteed order NASA will make under the Commercial Crew Transportation Capability (CCtCap) contracts. Boeing received its two orders in May and December of 2015, and SpaceX received its first order in November 2015. Both companies have started planning for, building and testing the necessary hardware and assets to carry out their first flight tests, and ultimately missions for the agency.

At a later time, NASA will identify which company will fly the first post-certification mission to the space station. Each provider's contract includes a minimum of two and a maximum potential of six missions.

SpaceX met the criteria for this latest award after it successfully completed interim developmental milestones and internal design reviews for its Crew Dragon spacecraft, Falcon 9 rocket and associated ground systems.

"We're making great progress with Crew Dragon, with qualification of our docking adapter and initial acceptance testing of the pressure vessel qualification unit completed" said Gwynne Shotwell, SpaceX president and chief operating officer. "We appreciate the trust NASA has placed in SpaceX with the order of

another crew mission and look forward to flying astronauts from American soil next year."

SpaceX is building four Crew Dragon spacecraft at its Hawthorne facility — two for qualification testing and two for flight tests next year. The company also is in the process of modifying Launch Pad 39A at NASA's Kennedy Space Center in Florida, from which the company will launch future crewed missions to the space station.

A standard commercial crew mission to the station will carry as many as four crew members and about 220 pounds of pressurized cargo, and remain at the station for as long as 210 days, available as an emergency lifeboat during that time.

"With the commercial crew vehicles from Boeing and SpaceX, we will soon add a seventh crew member to space station missions, which will significantly increase the amount of crew time to conduct research," said Julie Robinson, NASA's International Space Station chief scientist. "Given the number of investigations waiting for the crew to be able to complete their research, having more crew members will enable NASA and our partners to significantly increase the important research being done every day for the benefit of all humanity."

Orders under the CCtCap contracts are made two to three years prior to actual mission dates in order to provide time for each company to manufacture and assemble the launch vehicle and spacecraft. Each company also must successfully complete a certification process before NASA will give the final approval for flight.

NASA's Commercial Crew Program manages the CCtCap contracts and is working with each company to ensure commercial transportation system designs and post-certification missions will meet the agency's safety requirements. Activities that follow the award of missions include a series of mission-related reviews and approvals leading to launch. The program also will be involved in all operational phases of missions.

This artist's concept shows a SpaceX Crew Dragon docking with the International Space Station, as it will during a mission for NASA's Commercial Crew Program. NASA is partnering with Boeing and SpaceX to build a new generation of human-rated spacecraft capable of taking astronauts to the station and back to Earth, thereby expanding research opportunities in orbit. Image credit: SpaceX

ISS



Dirt flies out as the mock-up of a Boeing CST-100 Starliner lands as part of testing on the spacecraft's landing system including airbags designed to absorb the shock of impact. Photo credit: NASA



# KICKING UP DUST

## NASA, Boeing simulate return from low-earth orbit Commercial Crew mission

BY SASHA ELLIS,  
NASA'S LANGLEY RESEARCH CENTER, VIRGINIA

**H**oisted about 30 feet in the air, a mockup of Boeing's CST-100 Starliner spacecraft awaits its encounter with a pad full of dirt.

"Three, two, one" projects over the loud speaker just before the spacecraft is released and makes a loud thud when meeting the dirt. Six attached airbags absorb much of the landing impact and stabilize the spacecraft.

Boeing and NASA engineers at NASA's Langley Research Center in Hampton, Virginia, kicked off an initial series of six land landing qualification tests to simulate what the actual spacecraft and crew may experience after returning to Earth from the International Space Station.

The spacecraft is being developed in collaboration with NASA's Commercial Crew Program.

According to Boeing test engineer Preston Ferguson, the team at Langley is simulating the worst possible landing velocities and angles the spacecraft could experience while making its landing in the American Southwest.

"We have to verify the capability of landing at enveloping capsule and soil conditions to make sure that the vehicle will be stable and that the crew will be safe under expected parachute landing conditions," Ferguson explained.

Before beginning the land test series, the team wrapped up the last of 14 abort water landing scenarios at Langley's 20-foot-deep Hydro Impact Basin. Each scenario simulated an unlikely emergency during launch or return from the station. It also helped engineers understand and test the airbag and up-righting systems that protect astronauts.

After collecting, analyzing and implementing the data from both the water and land tests, Langley and Boeing will install two anthropomorphic test dummies inside the capsule. This second series of land tests with a simulated test crew will help NASA and Boeing understand how land landings will impact the crew by directly measuring the accelerations from instrumentation within the dummies.

The test dummies represent a 105-pound woman and a 220-pound man and are currently being used for water impact tests of NASA's Orion spacecraft, which are also conducted at Langley's Hydro Impact Basin.

NASA's Commercial Crew Program contracted Boeing and SpaceX to build the Starliner and Crew Dragon, respectively, as part of the effort to return America's ability to launch crews to low-Earth orbit and the International Space Station.

***"We have to verify the capability of landing at enveloping capsule and soil conditions to make sure that the vehicle will be stable and that the crew will be safe under expected parachute landing conditions."***

**– Preston Ferguson  
Boeing Test Engineer**



# Q & A



## Commercial Crew astronauts discuss progress, training with employees

BY STEVEN SICELOFF



The panelists took questions from the audience and from other NASA centers during the event. Photo credits: NASA/Kim Shiflett

There are few days that are the same for NASA's Commercial Crew Program astronauts as they train for flight tests aboard the next generation of human-rated spacecraft, astronauts Eric Boe and Suni Williams told an audience at NASA's Kennedy Space Center on Thursday.

"One of the things I like about being an astronaut is that you're always doing different things," Boe said. "I don't think I have a day or week that's been the same since we started this."

Williams said the constant changes involved in training are similar to what happens during a space mission, so the daily differences are valuable for the crews.

"This is not work, this is fun," Williams said. "It's pretty spectacular the stuff we get to do, but it's not all the same. It's not routine and I think that's good training for space. Up there, day-to-day, every day your timeline changes."

Astronauts Boe, Williams, Bob Behnken and Doug Hurley have not been assigned to specific missions or spacecraft, so all four are cross-training and advising on the development of both Boeing's CST-100 Starliner and SpaceX's Crew Dragon. All four

flew on space shuttle missions and have visited or lived aboard the International Space Station during their careers. They each also served as test pilots during their military careers.

Boeing and SpaceX are working toward conducting orbital flight tests of their spacecraft without a crew next year, then progressing toward a flight test for each including astronauts before they begin operational missions to take astronauts to the space station. The new launch capability will enhance research opportunities on the orbiting laboratory by doubling the amount of time astronauts working in space have to devote to scientific investigations.

Both companies will launch their spacecraft from Florida's Space Coast using spacecraft, rockets and support networks they own and operate. That approach is novel for NASA's human spaceflight programs which have always been designed, owned and operated by the agency itself in the past.

Taking questions from around the agency during the Kennedy event, Boe and Williams were joined by Bob Cabana, director of Kennedy and a former space shuttle commander, and Kathy Lueders, manager of the Commercial Crew Program.

### *What is the progress of the Commercial Crew Program?*

**Lueders:** I think people forget about the time frame and how short the time has been that our partners have been working on the final development of their spacecraft. We awarded the contracts in September 2014. Right now, the companies are in the midst of this grueling periods of getting their vehicles together and getting their structural test articles together. We're getting ready for flight tests. Most importantly, we're getting there as fast as we can safely fly.

### *What opportunities do you have working on a developmental program?*

**Boe:** We haven't worked on a new manned space program in the United States in more than 30 years, so it's a great honor for all of us. We're also working on Orion that will take us to Mars one day. These all work together for what we're doing. We're going to have people on Mars at some point and a big reason we have the station is to do the research that's needed to make that possible. So as you can tell, we're getting closer to flights and we'll probably start picking up the pace of our training efforts as we get into the fall.

**Williams:** Now is a good time to try new things. We're really taking advantage of 22 years of technological advances. That might take us out of our comfort zone, but we shouldn't be afraid of that.

### *What's the biggest challenge you've seen so far in CCP?*

**Williams:** We think we have an idea of what's going to happen, and we start to talk about it, then other ideas come in and change starts to happen and that's where you see the advances. It's challenging because you have to change your mindset.

**Boe:** When you make a new thing, it's hard work and it's an honor to be able to see these spacecraft and systems and to see the people who are making these things and making these changes. When you make something new, you have to be able to balance the work to get the right allocation and use.

### *How much faith do you put in engineers or do you go through all the engineering yourself? How much do you trust companies?*

**Williams:** There is just too much information to go through every single part of a spacecraft or an aircraft for that matter. We got to be involved almost a year ago so we were able to provide a perspective of what was being designed for. We have to trust them. The safety stuff is going to happen, everyone knows that and everyone works toward that. It's our obligation to make the spacecraft as good as it can be for the future crews as well.

**Boe:** Spaceflight is about people. When you fly airplanes you have to count on those people. The hardware is cool, but it's really the people that make everything work.

### *What do you think of the changes you are seeing at Kennedy?*

**Boe:** It's amazing to see Pad 39A getting modified by SpaceX. It's hardware and to me it shows that we are moving right along and 2017 and early 2018 are coming up fast. It's really amazing to see an old building like the Commercial Crew and Cargo Processing Facility completely remade on the inside like Boeing did to make it into a Starliner factory.

**Williams:** To me this is not a museum, it's an active spaceport. This is big hardware that's getting modified and getting built and I just can't help but tell a lot of people to come out here and see what is going on. It's not just where shuttles used to fly, it's where new vehicles are getting ready to fly. It's happening and it's happening quickly.

### *What would you say to the children who first walk on Mars?*

**Williams:** Don't forget to turn around and look at your home planet.

**Boe:** Have fun! We see Mars from Earth and it's a little thing and when they are going to look back on Earth from Mars and see the same thing, that's going to be pretty amazing.





# FACES OF GSDO

## GROUND SYSTEMS DEVELOPMENT & OPERATIONS



**Joy Mosdell**  
Schedule Analyst, Millennium Engineering and Integration  
Ground Systems Development & Operations Program

KENNEDY SPACE CENTER  
Exploration Begins Here

## Joy Mosdell

Schedule Analyst, Millennium Engineering and Integration

**M**y name is Joy Mosdell. I am the schedule analyst lead with Millennium Engineering and Integration for the Ground Systems Development and Operations Program (GSDO) at Kennedy Space Center.

I've worked a combination of 15 years at Kennedy and Cape Canaveral Air Force Station beginning in 2001. Prior to GSDO, I worked on the Boeing Delta IV and Delta II Programs, and at the NASA Applied Technologies Laboratories. I also supported the U.S. Air Force for Atlas V.

Currently, I'm responsible for leading the schedule team and all of the schedule analysts that support GSDO divisions. I directly support the mission manager and the program manager in all things schedule related. I also am the GSDO schedule focal point for cross-program, schedule-related issues. I work directly with the Space Launch System and Orion Programs, and also the Exploration Systems Division.

The coolest part of my job is being able to interact with almost everyone on the GSDO Program. From the program manager to the lower-level engineers, and those doing all of the designs and working on the systems. I also have the opportunity to work with the other programs as well.

The achievement I'm most proud of is how much the schedule team has achieved during the past four years. Schedules have taken priority in the program. We're now in the fabrication and testing phase. We had a team that wasn't performing as well as they could. I worked to make the schedules stronger and healthier, and now the schedules are the focal point of the program. We have the right people in the right places. Now, we're very much respected in the program.

I first became interested in space in 1997 when I was in the Air Force. I was a missile launch control officer in Minot, North Dakota. I knew about the space shuttle, but I didn't really have a great concept of what else was launched from Florida. I received an assignment to work on the Boeing Delta II Program. When I came to the Space Coast I was exposed to all of the different rocket programs and saw my first space shuttle launch. That's when I decided that I wanted to stay here. I left the Air Force and started working for Boeing on the Delta IV Program. I just realized that this is where I needed to be — in aerospace.

I was born and raised in Cleveland, Ohio. I moved to Florida in February 2001. I earned a Bachelor of Arts in political science from Miami University in Ohio. I earned a Master of Science in public administration from Central Michigan University in Mount Pleasant.

The advice I would give to students who are interested in a career similar to mine is to be really dedicated to the job. You need to have the passion for it. It's a very unique job. There are long days. Every day is a little bit different. I would advise students to study engineering. I don't have an engineering degree, but I'm in a technical field because of my background in the military. If I had known then, in high school, what I know now I would have pursued engineering in college.

I'm looking forward to the successful launch of NASA's Space Launch System rocket and Orion spacecraft in a couple of years. We've come so far in the past four years, from early designs to actually fabricating and testing. It would be great if NASA has a rocket that can do something that no one else has done. It's very exciting, and we're almost there. I'd like to see the program be successful.





The Orion heat shield for Exploration Mission 1 (EM-1) is secured inside the Neil Armstrong Operations and Checkout Building high bay at Kennedy Space Center. The heat shield arrived aboard the agency's Super Guppy aircraft at the Shuttle Landing Facility from Lockheed Martin's manufacturing facility near Denver. The heat shield will be moved onto a test stand to begin processing. The Orion spacecraft will launch atop NASA's Space Launch System rocket on EM-1, an uncrewed test flight, in 2018.  
Photo credit: NASA/Dimitri Gerondidakis





The Orion crew module for Exploration Mission 1 was transferred into the clean room inside the Neil Armstrong Operations and Checkout Building at Kennedy Space Center in late July to begin installation of the spacecraft's critical systems, including propellant lines. Photo credit: NASA

# WELDING THE LINES

## Orion crew module reaches processing milestone

BY LINDA HERRIDGE

**A**ssembly 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 Kennedy Space Center. 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 cleared the high bay and performed inspections of the welds for any imperfections. This process will be repeated as each of the remaining tube assemblies is completed along the exterior of the crew module.

"Completion of the first Orion propulsion system welds marks an important milestone for production of the next spacecraft for flight," said Scott Wilson, NASA manager of production operations for the Orion Program. "We are moving from assembling structure to installing the critical systems that will propel Orion farther and farther from Earth than human-capable spacecraft ever have journeyed."

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.

"These first propulsion system welds marks a significant transition during the build-up of the crew module, signifying the completion of the structures assembly and the beginning of the fluid systems integration," said Jules Schneider, Orion KSC operations manager with Lockheed Martin.

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.

Orion is the NASA spacecraft that will send astronauts to deep-space destinations, including on toward the journey to Mars. The pressure vessel will contain the atmosphere that a crew would breathe during a mission. It also will provide living and working space for the crew, and withstand the loads and forces experienced during launch and landing.

The SLS rocket with Orion atop is targeted to launch from Kennedy's Launch Pad 39B in 2018. EM-1 will send Orion on a path thousands of miles beyond the moon over a course of three weeks, farther into space than human spaceflight has ever travelled before. The spacecraft will return to Earth and safely splash down in the Pacific Ocean off the coast of California. The mission will advance and validate capabilities required for human exploration of Mars.

"Our human journey to Mars is underway. It is milestones like these that mark our progress to deep space," Wilson said.



# MOD TESTING

## Multi-Payload Processing Facility provides 'gas station' for Orion

BY BOB GRANATH

Mars



The 19,647-square-foot Multi-Payload Processing Facility is where Orion will receive its flight load of propellant, high pressure gasses and coolant. After years of design work, state-of-the-art equipment now is being tested. Photo credit: NASA/Ben Smegelsky

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 Kennedy Space Center.

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

"After years of design work and installation of state-of-the-art equipment, we now are testing elements of the facility," said Skip Williams, project manager for the spacecraft offline element integration team. "This is the validation and verification phase to make sure we're ready when Orion's crew module (CM) and its service module (SM) arrive before EM-1."

EM-1, or Exploration Mission 1, will be Orion's first flight atop the Space Launch System (SLS) rocket. During the three-week mission, the spacecraft will venture 40,000 miles beyond the orbit

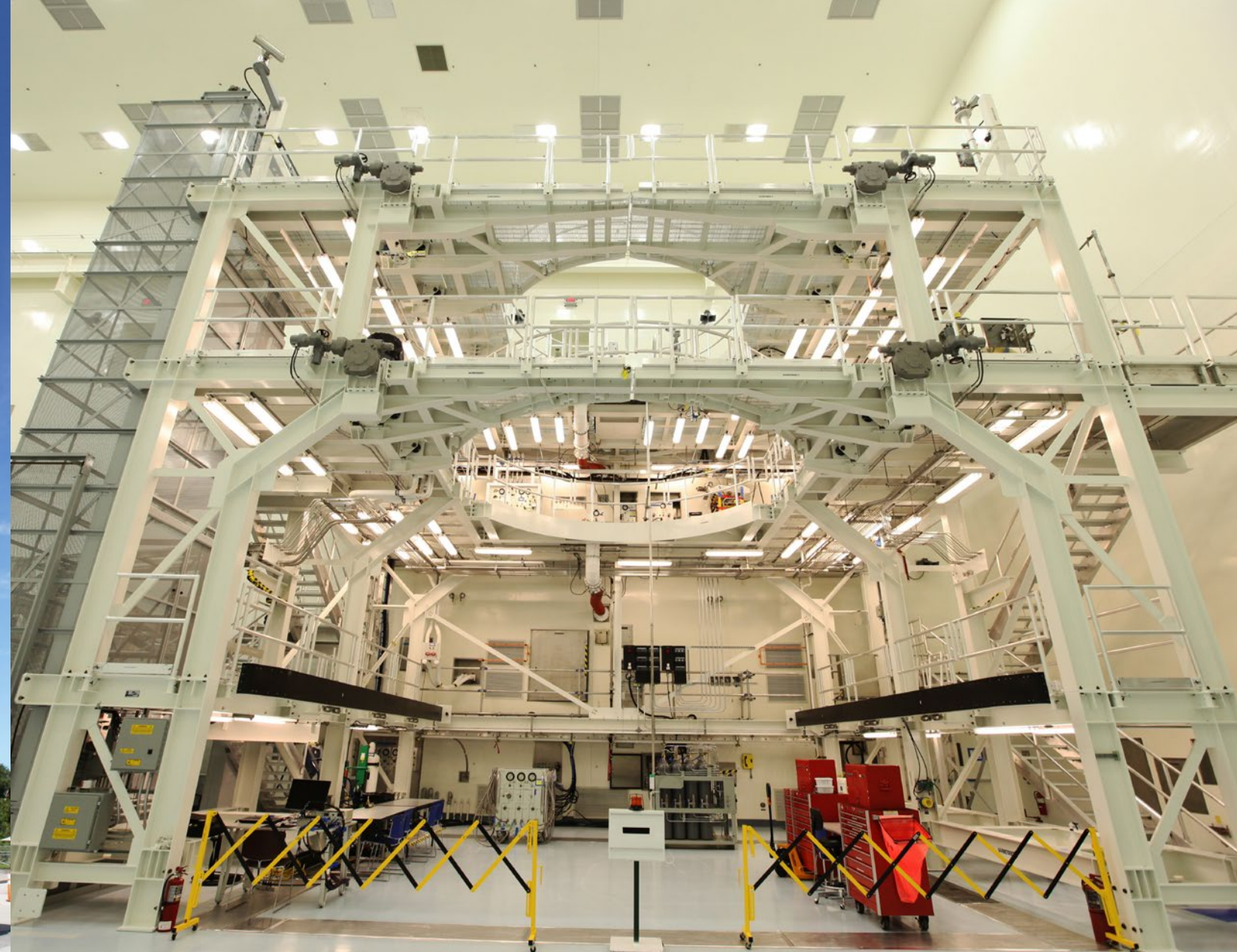
of the moon, farther than any spacecraft built for humans has ever traveled, testing the systems needed for the agency's journey to Mars.

The 19,647-square-foot MPPF originally was constructed in 1995. True to its name, the facility can accommodate one or more payloads in processing at the same time depending on their size.

An example of the MPPF's abilities included payload processing for space shuttle missions STS-95 and STS-88. Also, prior to STS-99, the large Shuttle Radar Topography Mission payload was tested and verified, occupying more than 95 percent of the facility's high bay space.

Design work to support Orion began in 2007. The Boeing Design Lab helped develop the complex, integrated engineering strategy for the facility.

The extensive upgrades and modernizations began in 2013. It was a part of Kennedy's Ground Systems Development and Operations Program's overall effort to build a premier, multi-user



The Orion service platform that will be used for offline processing and fueling of the Orion spacecraft and service module stack before launch is seen inside the Multi-Payload Processing Facility at Kennedy Space Center. Modifications now are complete with validations and testing underway. Photo credit: NASA/Ben Smegelsky

spaceport.

"Just about everything in the building from the floor to the ceiling was modified to support Orion," said Leo DeCesare, Construction of Facilities project manager in Kennedy Engineering. "That includes extensive pipelines in the walls to support the new environmental control system and carry the commodities that will be loaded aboard the spacecraft."

According to Williams, a second processing stand like the one that will surround Orion could be built and accommodated by the current facility infrastructure.

"There is room inside this high bay to accommodate a test stand of similar size," he said. "We are building this to not only support Orion, but other payloads that could benefit from the capability we're building into this facility."

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 MPPE.

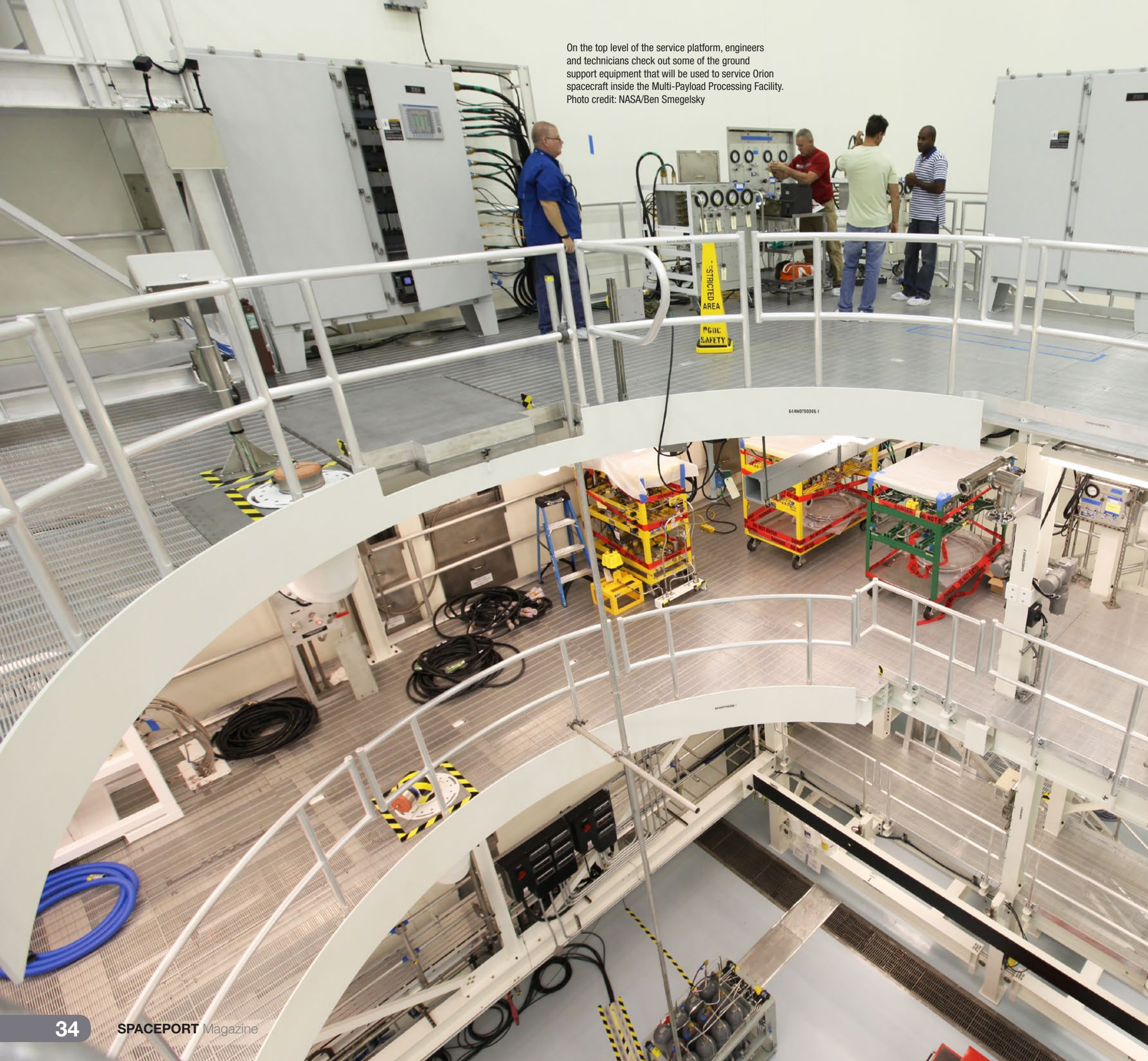
"When Orion arrives here, its tanks are empty," said Williams. "This is where we load monomethyl hydrazine and nitrogen tetroxide for the service module main engine and the crew module and service module reaction control thrusters. Also, ammonia for the cooling system and a Freon loop for the service module heat exchanger."

The thrusters provide the spacecraft with steering capabilities while flying in space and as it plunges through the atmosphere during re-entry. The heat exchanger helps cool electronic systems while powered up on the ground.

Due to the hazardous nature of the fueling operation, technicians will wear self-contained atmospheric protective ensemble, or SCAPE, suits. These breathing air supplied rubber garments provide protection in the event they are exposed to the highly toxic hypergolic fuel or oxidizer.

These activities can be monitored, and mostly, controlled from





On the top level of the service platform, engineers and technicians check out some of the ground support equipment that will be used to service Orion spacecraft inside the Multi-Payload Processing Facility. Photo credit: NASA/Ben Smegelsky

the Firing Room in the Launch Control Center (LCC). DeCesare pointed out that adjacent to the processing high bay is the communications room with state-of-the-art monitors and control systems to make this possible.

“Our instrumentation is connected to the LCC where test conductors can follow the loading of the commodities,” he said. “In addition to the instrumentation, the platforms that surround the vehicle are equipped with operational TV cameras so test conductors can look in on these operations.”

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.

Williams noted that much of the ground support equipment in the MPPF is on wheels.

“This will make it easier to move things around to support other payloads that may be processed here,” he said. “In addition, this is considered a class ‘100K,’ clean room.”

The “100K” or 100,000 clean room designation signifies that there are less than 100,000 particles greater than half-micron in size in any cubic foot of air. This provides an environment in which sensitive spacecraft systems are protected from contaminants.

Upgrades also include installing new pneumatics systems for

gaseous helium, gaseous oxygen, gaseous nitrogen and breathing air and a ground cooling system, all necessary to process a human-rated spacecraft.

The facility also is equipped with a 40,000-pound capacity crane to move equipment and has backup generators in the event of a power failure.

The MPPF also will be the first stop when Orion returns from space.

“We’ll de-service the spacecraft to remove any of the commodities left in its tanks,” Williams said. “Since much of these elements are hazardous, we don’t want them leaking somewhere else.”

Now that the upgrades and modifications are complete, testing is underway.

“Validations began on July 7 and will continue through July of next year,” DeCesare said.

Williams had high praise for those who worked on the MPPF modification project since it began in 2007. It included teams from the Kennedy Engineering directorate, NASA’s Engineering Services Contract (ESC) organization, Jacobs Technology under the Test and Operations Support Contract (TOSC), most NASA centers, especially the Orion Program office at the Johnson Space Center in Houston, and numerous NASA contractors along with ESA (the European Space Agency), which provided expertise on requirements for vehicle processing.

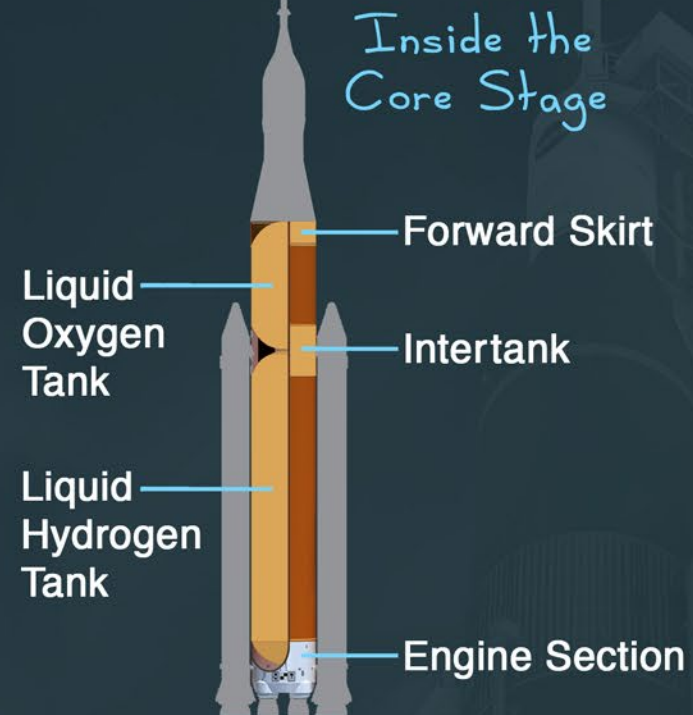
“Many contributed to the successful project,” he said. “A lot of credit goes to those folks.”

For more about NASA’s Orion spacecraft, go to <http://www.nasa.gov/orion>



# CORE STAGE 101\*

\* Or: What you need to know about the Space Launch System Core Stage, the backbone of the rocket.



## How Big is the SLS Core Stage?

- **212** Feet tall
- **27.6** Feet in diameter
- **~2.3M** Pounds with propellant
- Largest rocket stage ever built
- Fuels world's most powerful rocket
- Fast ride – reaches Mach **23**, faster than **17,000** MPH in **8.5** min

#JourneyToMars @NASA\_SLS

1

### Engine Section

- Delivering propellants from LH<sub>2</sub> and LOX tanks to **4** RS-25 engines
- Avionics to steer the engines
- Booster attach point

2

### Liquid Hydrogen (LH<sub>2</sub>) Tank

- Holds **537,000** gallons of LH<sub>2</sub> cooled to **-423** °F

3

### Intertank

- Joins LOX and LH<sub>2</sub> tanks
- Booster attach point
- Houses avionics and electronics

4

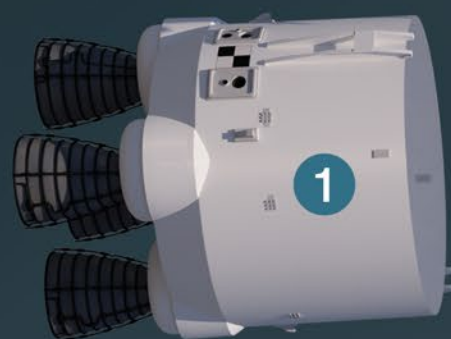
### Liquid Oxygen (LOX) Tank

- Holds **196,000** gallons of LOX cooled to **-297** °F

5

### Forward Skirt

- Houses flight computers, cameras, and avionics — the “**brains**” of the rocket



- Fuels **4** engines to produce a total of **2M** pounds of thrust

### LH<sub>2</sub> & LOX Tanks

- Holds **733,000** gallons of propellant, enough to fill **63** large tanker trucks.



BIGGER TANKS. BOLDER MISSIONS.

#SLSFiredUp



# FROM TOP TO BOTTOM

## Pad 39B infrastructure upgrades to support NASA's journey to Mars

BY LINDA HERRIDGE

Refurbishment and upgrade of the water system included installation of a new sewage lift system that will pump sewage from the pad's liquid hydrogen and liquid oxygen areas to the main pad sewage line. Photo credit: NASA



Launch Pad 39B at Kennedy Space Center is undergoing a metamorphosis from top to bottom to support the agency's Space Launch System (SLS) rocket with the Orion spacecraft atop for their first integrated uncrewed flight test. While modifications to the surface of the pad and ongoing work in the flame trench are visible, upgrades to other systems may not be as obvious, but are vital to ensuring safe and successful launches into deep space and the journey to Mars.

"We have been steadily working a series of projects to modernize or refurbish every part of the pad," said Regina Spellman,

launch pad senior project manager in the Ground Systems Development and Operations Program (GSDO). "Upon completion of this group of projects, we are entering the home stretch in our preparation for the first launch."

These upgrades include a new communication system; new heating, ventilation and cooling system; replacement of water system piping in the pad perimeter; and installing new ignition overpressure/sound suppression bypass valves at the valve complex. All of these improvements, while not so glamorous, are necessary to support pad prelaunch processing and

launch requirements for SLS and the Orion spacecraft stacked and secured atop the mobile launcher on the pad.

"There is still a lot of work to be done, but you can definitely feel the excitement starting to build as Pad B nears being operational once again," said Lori Jones, an engineer and project manager for Construction of Facilities for the pad.

GSDO is overseeing upgrades to Pad 39B and other facilities to support NASA's deep-space missions and the transition to a multi-user spaceport.



Phase 2 of refurbishment and upgrades to the pad B water systems included installation of new potable and non-potable water pipes. Several three-inch potable lines will feed the safety showers and eye wash stations throughout the pad area. A 12-inch non-potable line will feed the low pressure fire suppression system and fire hydrants throughout the pad area. Photo credit: NASA

***"Upon completion of this group of projects, we are entering the home stretch in our preparation for the first launch."***

– Regina Spellman

Launch Pad Senior Project Manager

Ground Systems Development and Operations Program

### HVAC AND CONTROLS

Refurbishment of the heating, ventilation and air conditioning (HVAC) systems inside the Pad B perimeter was completed in July 2016. The HVAC systems in the Operations Support Building I and Logistics Building in the nearby Launch Complex 39 area also were upgraded and completed in July. A construction contract was awarded to RUSH Construction Inc. of Titusville, Florida, in 2013 to perform the work.

### REFURBISH AND UPGRADE WATER SYSTEMS

New potable and non-potable system piping was installed within the pad perimeter. Some of the associated above-ground system components that had deteriorated were refurbished or replaced. Some of the domestic wastewater systems within the Pad B perimeter also were replaced. A construction contract was awarded to RUSH Construction Inc. in September 2013. The project was completed in July 2016.

### IGNITION OVER PRESSURE/SOUND SUPPRESSION (IOP/SS) POST-LIFTOFF BYPASS

The IOP/SS uses a large volume of water to prevent damage to the rocket from the exhaust and acoustic shock wave during launch. Installation of a bypass in the post-liftoff portion of the IOP/SS system at the Pad B valve complex was completed in July. The new bypass system will enable the flow of water through the mobile launcher's deck water nozzles, also known as rainbirds, prior to T-0 to prevent it from impacting the SLS rocket in the event of an on-pad abort very late in the launch countdown. At T-0, the main 48-inch valves located in the IOP/SS valve complex will open to ensure the flow and timing requirements are achieved. A construction contract was awarded to Sauer Inc. of Oak Hill, Florida, in September 2014 to complete the project.

### COMMUNICATIONS SYSTEM

To prepare for a new communications system, all of the Apollo and space shuttle era equipment in the Pad Terminal Connection Room and the pad perimeter were removed, including all switches and electronic devices, paging speakers, digital keysets, telephones, communication racks and more than 592,000 pounds of cabling. Updated communication equipment was installed, including new network switches, Lightning Protection System, cameras, telephones, paging speakers, and more than 104,000 feet of new cabling.

Communication Systems upgrades will include new fiber optics from the pad to the Launch Control Center, the outdoor cable plant and communications rooms.

The new communications system will support staff and customers at the pad for pad safety, various leak detection and range safety subsystems, radio frequency and telemetry, cryogenics, the Environmental Control Subsystem, and the ground cooling subsystem.

All of the Pad B designs were created by the Information Technology (IT) organization with support from the Information Management and Communication Support (IMCS) contractor team for GSDO. IMCS, with support from other contractors, is performing the work. The project was awarded in January 2010 and is targeted for completion in late September.

Upgrades to the surface of Pad B as well as the systems below and surrounding the pad will support the new processing and launch requirements for SLS and the Orion spacecraft for Exploration Mission-1 and deep-space missions, including the journey to Mars. The modifications and improvements to processing and launch facilities will support Kennedy as a multi-user spaceport for government and commercial launches for years to come.



# FEEL THE BURN

## Agreement makes it easier to schedule prescribed burns at Kennedy

BY FRANK OCHOA-GONZALES

It wasn't always easy to schedule a prescribed burn. In the past, the process was based on the U.S. Fish and Wildlife Service (USFWS) requesting to do a burn in one of the 29 specific parcels that make up the Merritt Island National Wildlife Refuge (MINWR), on which Kennedy Space Center is located. It is the USFWS's responsibility to manage the MINWR, which includes conducting prescribed burns. Prior to the process change, hundreds of officials, from both Kennedy and the 45th Space Wing (45 SW), had "GO/NO GO" authority whether to burn or not; it only took one "NO GO" to keep the burn from occurring. A "NO GO" response could have been for a number of reasons; most were valid, while others, questionable.

To improve the process, the Prescribed Burn Working Group, a multiagency group with members from the 45 SW and Kennedy, was requested to sit down and decide the best way to move forward. Dozens of organizations were represented and Kennedy's Customer Services and Integration Branch, from the Spaceport Integration and Services (SI) Directorate, was there to represent Kennedy. After some negotiation, a short list of rules was drawn up and agreed to by all parties from both Kennedy and the 45 SW. In April, Kennedy, the 45 SW and the USFWS signed the Memorandum of Understanding (MOU). The MOU gave the USFWS more autonomy to conduct prescribed burns on Kennedy; the agreement is good for three years. The Kennedy Customer Services and Integration Branch plays a key role in this new process. It is their responsibility to coordinate, with our Institutional Support Contractor's assistance, the USFWS's burn requests with all the programs and customers that operate at our multi-user spaceport.

According to Lynne Phillips, a physical scientist at Kennedy, the MOU has been working well and better than the previous process.

"Customer Services and Integration Branch (SI-I1) has been the pivotal aspect of the beneficial changes that we have seen," Phillips said. "They insure all parties are coordinating and complying with the agreement, which has resulted in more opportunities for the MINWR Fire Crew to perform necessary prescription burns to protect both the natural habitats and KSC infrastructure."

In a nutshell, the fire crew identify areas that should be burned under specific conditions and SI-I1 present the burn sensitive areas for the time frame identified for burning.

The vetting process includes a variety of variables that must be considered before the decision to

Seen is a prescribed burn along Wisconsin Village Road just west of the SLF in 2015. Photo courtesy of U.S. Fish and Wildlife Service



proceed is made. The MOU allows for a better review and assessment for both parties that has resulted in more burns and reduced threat for wildfire.

“We transitioned that process into a defined set of about a dozen rules that work,” said Kennedy spaceport integrator Bill Heidtman, “and it is going very well.”

Kennedy is a Center of Excellence in the environmental stewardship and land management arena. Located on MINWR, Kennedy is managed by the USFWS through an interagency agreement. The USFWS has the responsibility for wildland firefighting and prescribed burning on MINWR and Kennedy and to enforce federal laws for the protection of species and their habitats. The 45 SW manages the burns across the river with a contracted third party.

The USFWS conducts prescribed burns for two reasons. The first reduces hazardous fuel loads around Kennedy infrastructure and surrounding communities, thereby reducing the likelihood of a catastrophic wildfire. The second improves or restores wildlife habitats to pre-fire exclusion conditions to promote and benefit threatened and endangered species that are dependent on fire adapted ecosystems.

So far, the USFWS has burned about 17,500 acres this calendar year. It hopes to reach 22,000 by year’s end. Michael Good, prescribed fire specialist of the U.S. Fish and Wildlife Service, says the USFWS is about 20,000 acres behind, but hopes to make it up in the next couple of years with process improvements implemented through the execution of the new agreement. The goal each year is to burn

15,000 to 20,000 acres. Under the old prescribed burn process in 2014, there only were six days of unrestricted burning. That added to the backlog.

“Instead of asking permission to burn, we notify when we are going to burn, knowing the standard rules and what restrictions are in place,” said Mike Good. “The new process allows us to better focus our efforts on the actual prescribed burn implementation.”

The burns, which are supported by several surrounding firefighting agencies, are conducted to weed out overgrowth, including grasslands, vegetation, shrubs and trees that could become a threat during the upcoming dry season.

Before any prescribed fire is started, the refuge fire management staff, under guidance from the fire management officer or prescribed fire specialist, carefully considers many factors to ensure the burn will safely meet all management objectives. Weather forecasts, humidity levels, predicted wind speed and direction, fuel types, time since the last burn, and topography are all very important factors of preparing for any prescribed burn. All fire-trained / “red card” qualified firefighters who will assist with the prescribed burn attend a pre-burn safety briefing to discuss all aspects of the planned burn and identify what will be done in case the fire burns outside the controlled area or perhaps is not meeting habitat objectives. A small test burn, within the unit, allows for a field litmus test to make the final determination whether the burn is a “GO or NO GO”.

“The amount of effort, science training, and time we put into these prescribed burns is incredible,” said prescribed fire specialist Mike Good of the U.S. Fish and Wildlife Service. “Each burn takes months of advance planning.”

One tool that is used to keep Kennedy’s workforce in the loop is called GeoSIMS (GeoSpatial Integrated Master Schedule). It visually depicts contamination buffers around certain areas on a daily basis. However, with few exceptions, only Kennedy employees are able to view the internal website.

Where smoke-sensitive payload processing or sensitive operations are being conducted, there is a default two-mile buffer around those facilities or operational areas. “However, if a sensitive payload is being processed in a particular facility requiring a greater contamination buffer size, then we will honor that greater requirement,” Kennedy spaceport integrator Greg Gaddis said. “For example, there is a three-mile, no-smoke radius around the Payload Hazardous Servicing Facility (PHSF), which housed the Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx) spacecraft prior to it being moved to Space Launch Complex 41 for mating atop the Atlas V rocket.”

Fire is a natural phenomenon and Florida’s natural habitats are dependent on fire to maintain optimal conditions for its indigenous and endangered wildlife. Both plants and animals in many parts of the world evolved in the presence of fire. Some species of plants at Kennedy, including some of the pine and grass species, have seeds that will not germinate if they are not exposed to the heat of a fire. The MINWR and Kennedy environmental goals are to protect and enhance our natural habitats and the wildlife they support while minimizing risks associated with uncontrolled wildfire like those that occurred in Florida in the summer of 2008 and on Center in 2011.

In the end, a new, improved process, a new visualization tool, more autonomy for the USFWS are in place, all in support of, and without impact to, Kennedy spaceport operations, while at the same time stepping up our game regarding environmental stewardship.

Seen is a prescribed burn southeast of the Vehicle Assembly Building in 2011. It was completed using a helicopter. Photo courtesy of U.S. Fish and Wildlife Service





Since August of 1963, Kennedy Space Center has coexisted with Merritt Island's National Wildlife Refuge. Just south of Launch Pad 39A, manatees graze protected in a sanctuary in the northern end of the Banana River. Between May and September, thousands of endangered sea turtles come ashore on this barrier island in the dark of night to lay their eggs. Merritt Island's strategic location along the Atlantic Flyway provides a resting and feeding place for thousands of ducks, wading birds, shorebirds and songbirds. Diverse habitats that include brackish marshes, salt water estuaries, hardwood hammocks and upland scrub provide homes to an amazing diversity of more than 500 species of fish and wildlife, including many that are protected under the Endangered Species Act. Today, these 220 square miles are managed by the Department of the Interior as a national wildlife refuge and national seashore with the exception of about 10 square miles dedicated to the launch, landing and processing facilities that support the space program. In this Q&A series about responsibilities of the KSC Ecological Program, we want to bring awareness surrounding prescribed fires and how they can mimic natural fire processes to benefit native, fire dependent species and their habitats. The Ecological Program is essential in protecting the landscape and wildlife inside our federal property boundaries.

**Question: Do natural lightning ignited fires occur on the Cape Canaveral/Merritt Island Barrier Island Complex?**

**Answer:** Yes, lightning ignited fires occur naturally.

**Q: How many cloud to ground lightning flashes does it typically take to start one fire?**

**A:** On average, one fire is started for every 881 cloud to ground lightning strikes.

**Q: Is ignition by cloud to ground lightning flash instantaneous?**

**A:** Sometimes; about half are delayed, as ignition smolders until conditions improve for combustion to occur vigorously and turn into a fire.

**Q: How does a lightning flash ignite a fire?**

**A:** Lightning ignition occurs as a result of a confluence of many conditions and the interaction of many factors. Factors such as lightning polarity (positive or negative charge), lightning flash multiplicity (number of strokes per flash), Long Continuing Current (time lightning dwells on fuels), fuel type and state (e.g., fine, coarse, wet or dry), peak current (strength), and meteorological conditions all play important roles in fire ignition. And finally, the placement of the ignited area and atmospheric conditions must be conducive to continued fire and spreading of the fire.

**Q: What are the characteristics of our natural lightning ignition regime?**

**A:** Lightning ignitions begin occurring in the spring with a peak in July and taper off in September, with fall and winter lightning fires being extremely rare. Records indicate an annual mean of 14 ignitions, with a minimum of 2 and a maximum of 39.

**Q: When was the peak in fire frequency and area burned, during our natural fire regime?**

**A:** The peak frequency of lightning ignition occurred during the month of July. However, the peak in area burned typically occurred in May – June, during the spring/early summer seasonal drought.

**Q: What were the size characteristics of our natural fire regime?**

**A:** Frequent, small fires dominated our natural fire regime particularly during the hot, humid summer lightning season with large, less frequent fire occurring during our annual spring/early summer drought.

**Q: How has human settlement impacted fire in east central Florida?**

**A:** Humans have disrupted the natural fire regime in many ways. They have suppressed fires leading to an unnatural build up in fuels and tree densities, changed the timing/seasonality of fire by setting fires year round, introduced exotic plant species altering

the flammability of the landscape, and have fragmented fuels with transportation routes, agricultural and urban development. All of these factors influence fire behavior and contribute to altering the natural fire regime.

**Q: How does fragmenting fuels affect the natural spread of fire?**

**A:** Research has shown that as little as 10 percent of land cover from urban, transportation and agriculture can cause as much as a 50 percent decline in fire extent. This is because non-flammable features on the landscape break up fuel continuity and interrupts fires spread.

**Q: Why are prescribed fires that mimic natural fire results so important?**

**A:** Fire was the primary maintenance process in the natural terrestrial environment within Florida. Native, fire dependent species of plants and animals depend on specific fire characteristics and require it to uphold their survival. Many species require habitat conditions maintained by fire such as height structure, openings, and bare sand. Others have a direct requirement, needing fire to germinate or release seeds. They have adapted to the natural fire regime over millions of years and some may not persist into the future without frequent, targeted fire management.

**Q: What can I do to help maintain a healthy landscape on KSC/MINWR for the persistence of our native fire dependent species?**

**A:** Prepare the exterior of your facility to be as inflammable as possible by clearing potential fuels that are close, and make facilities impervious to smoke by sealing building doors and windows and updating air conditioning/ventilation system filtration systems.

**Q: What is the role of fire management on human safety?**

**A:** In addition to the ecological benefits, prescribed fire management is a necessary component of human safety on KSC/MINWR. Suppressing fire leads to fuel build up that, when ignited under hot dry meteorological conditions, can be uncontrollable and hazardous. Smoke from suppressed fuels is uncharacteristically heavy and can reduce visibility to extremely low levels on roadways. Fuels grow rapidly, so we are all safer when fires are occurring frequently under controlled circumstances, reducing fuels and keeping smoke levels manageable.

**Q: What are some hidden benefits of fire?**

**A:** Fire creates charcoal which has two positive impacts when stored in our soils. First, it helps filter and clean water that runs off into our lagoons and percolates down into our aquifers. Secondly, it binds and stores carbon by removing it from our atmosphere where it will not be able to act as a greenhouse gas.

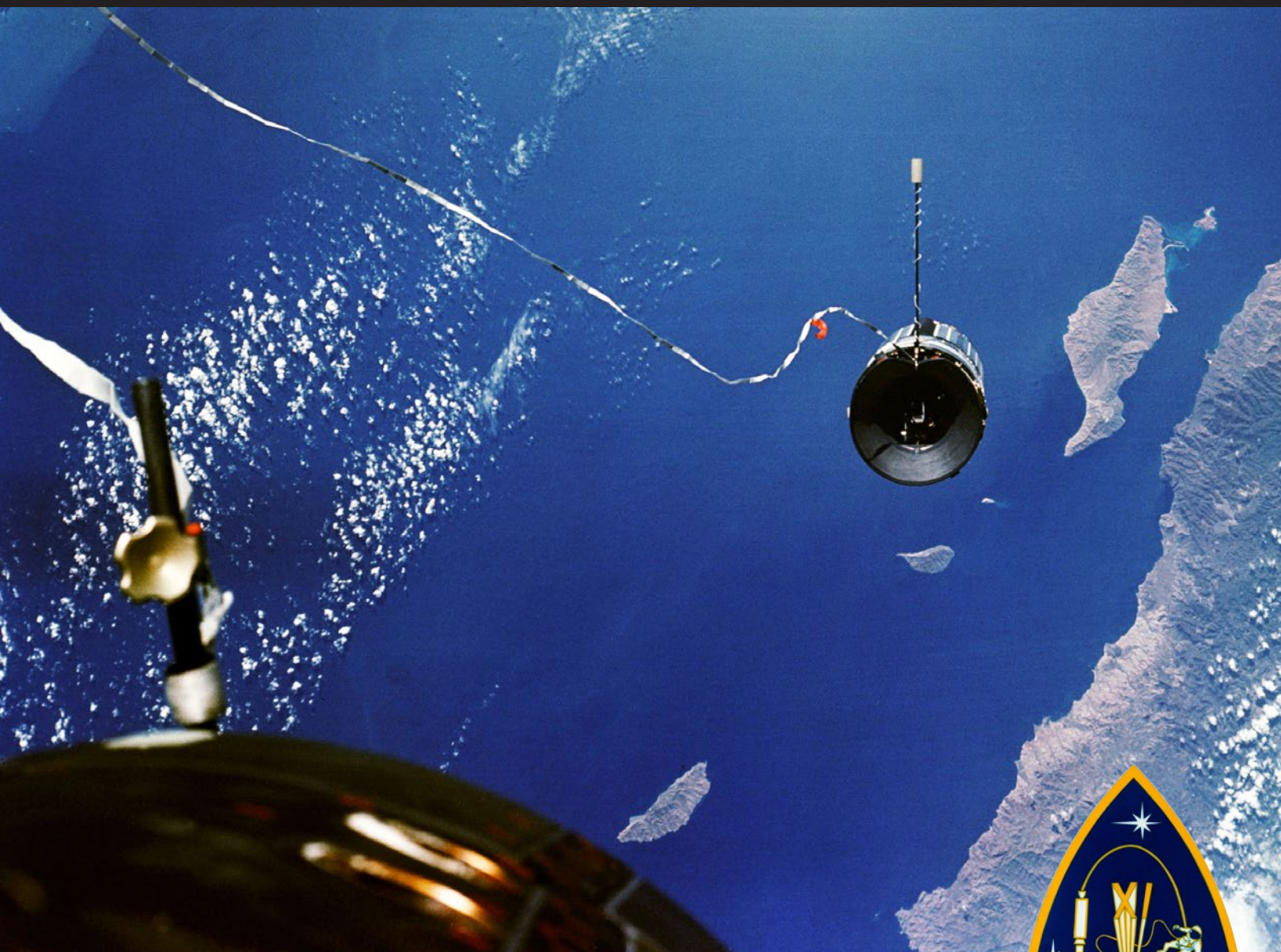
Seen is a prescribed burn in July along Kennedy Parkway just south of the Gate 4. Photo courtesy of U.S. Fish and Wildlife Service





# PROJECT GEMINI

PART 8



On Sept. 14, 1966, Gemini XI is tethered to the Agena. Conrad and Gordon are maneuvering their craft to keep the tether taut between the two. By firing their side thrusters to slowly rotate the combined spacecraft, they were able to use centrifugal force to generate about 0.00015 g of artificial gravity. Photo credit: NASA

## DYNAMIC DOCKING Demanding Gemini XI mission flies on top of the world

BY BOB GRANATH

"I tell ya from up here the world is round. It is spectacular. It's fantastic," said Gemini XI command pilot Charles "Pete" Conrad as he and pilot Dick Gordon looked down from their lofty vantage point. Their record-shattering altitude of 850 miles above the Earth was only one highlight of a demanding, three-day mission in September 1966.

The first rendezvous between two orbiting spacecraft occurred only nine months earlier. On each succeeding Gemini mission rendezvous had taken about four orbits — approximately six hours — to complete. But, when Apollo astronauts lift off from the moon, the lunar module was set to rendezvous with the command module on the first orbit. To advance NASA's capabilities and prove this was feasible, plans called for Conrad and Gordon to do just that — a "direct ascent" or first-orbit — rendezvous with a separately launched Agena target vehicle.

"This will impose a much tighter launch window on the Gemini ground crews," said Merritt Preston, deputy director of Launch Operations at NASA's Kennedy Space Center in Florida. "Essentially, we'll have to launch the Gemini space vehicle on an on-time basis. It will be a very short (launch) window."

Preston pointed out that several flights in the past had launched exactly on time.

"The teams have both the capability and the confidence to do the job," he said.

In addition to the link-up with an Agena and using its engine to boost Gemini XI to a record altitude, the flight plan called for two spacewalks by Gordon, each lasting more than two hours. There also would be a demonstration of "passive attitude stabilization" of the two spacecraft connected by a tether, creating artificial gravity by spinning the combination.

Conrad was a veteran of the eight-day Gemini V mission the previous year. A Naval aviator, he was a member of the agency's second group of astronauts. Conrad would go on to walk on the moon during Apollo 12 in 1969 and command the first Skylab mission in May and June 1973. A part of the third group of NASA astronauts, Gordon also was a Navy pilot making his first trip into space. He later would serve as command module pilot on Apollo 12.

On Sept. 12, 1966, the Agena was boosted to orbit on an Atlas rocket from Launch Complex 14 at Cape Kennedy (now Cape Canaveral) Air Force Station in Florida. Precisely on time, one hour and 37 minutes later, Conrad and Gordon lifted off in their Gemini atop a Titan II rocket from Launch Complex 19 at the Cape.

Preston, who also served as Gemini deputy mission director, hailed the NASA-industry team for their achievement at Cape Kennedy.



Gemini XI pilot Dick Gordon, left, and command pilot Charles "Pete" Conrad pose at the mission simulator during training at Kennedy Space Center on Sept. 7, 1966. Photo credit: NASA



Gemini XI lifts off from Cape Kennedy Air Force station's Launch Complex 19 on Sept. 12, 1966. Charles "Pete" Conrad and Dick Gordon were on their way to a three-day mission in Earth orbit. In the background is an Apollo Saturn V on Launch Complex 39A at Kennedy Space Center. Photo credit: NASA





After a first orbit rendezvous, Gemini XI is docked with its Agena. The target vehicle's antenna is seen extending upwards. Docking was achieved a mere one hour and 34 minutes after liftoff. Photo credit: NASA/Dick Gordon

“Launching the Atlas-Agena target vehicle within the desired time and then meeting a two-second launch window with Gemini presented one of the most difficult assignments for launch crews,” he said. “The fact that both windows were met, making possible a successful rendezvous in the first revolution, is a tribute to the outstanding work of the checkout and launch teams.”

Maneuvers for Gemini to catch up with Agena began quickly.

As Gemini XI passed over the tracking station at Tananarive (now Antananarivo), Madagascar, off the east coast of Africa, Conrad reported the Agena was in sight about 75 miles away.

By the time Gemini XI was approaching the Hawaiian Islands, Conrad said they were about eight miles away with the Agena gleaming in the sunlight.

“He sure is bright, isn’t he,” said Gordon in reference to the reflection.

By the time Gemini XI was coming up on the coast of California, Gordon told fellow astronaut John Young that they were flying in formation and ready to dock. Young was serving as capsule communicator, known as capcom, in Mission Control at the Manned Spacecraft Center (now Johnson Space Center) in Houston, Texas,

“You’re go for docking,” said Young.

“John, we are docked,” Conrad said, a mere one hour and 34 minutes after launch.

The first of Gordon’s two spacewalks began about 24 hours after liftoff. His task was to fasten a 100-foot tether on the Agena to the Gemini spacecraft for the “passive attitude stabilization” experiment.

“It’s a beautiful day,” he said as he floated out of the hatch.

Gordon removed the tether stored in the Agena’s docking collar, attaching it to the Gemini’s nose-mounted docking bar. To give himself an opportunity to work with both hands, he sat astride the spacecraft’s nose.

“Ride ‘em, cowboy,” said Conrad, encouraging his counterpart.

However, Gordon soon ran into problems similar to those encountered by Gene Cernan on Gemini IX and Mike Collins on Gemini X.

The task of attaching the tether was easy during training aboard the KC-135 aircraft which flew parabolas to create brief periods of weightlessness.

But working through extended periods without handholds proved far more difficult as Gordon tended to float away from his work making simple tasks more challenging.

Conrad asked, “How are you doing?”

“Tired, Pete,” said Gordon.

“All right,” Conrad said. “Just rest. You’ve got plenty of time.”

Several minutes into the spacewalk, Conrad reported to Mission Control that Gordon had the tether tightened on the Gemini’s docking bar, but “he’s breathing pretty hard.”

Due to the exertion, sweat was getting into one of Gordon’s eyes. Even though he rested for a few minutes, the sweat would not evaporate. Conrad decided to cancel an experiment with a power tool and end the spacewalk after only 33 minutes.

“Dick got so much sweat in his right eye that he couldn’t see any more,” Conrad said. “I didn’t want him to get any hotter doing any more work back there with the possibility of not being able to see out of the other one. So I called him in.”

The next task was a firing of the Agena’s 15,960-pound-thrust primary propulsion system (PPS) engine.

“Gemini XI, you have a go for the PPS burn,” said the capcom at the Canary Islands tracking station off the northwest coast of Africa.



"Ride 'em cowboy," said Gemini XI command pilot Charles "Pete" Conrad as pilot Dick Gordon attaches a tether from the Agena target vehicle to his spacecraft. This view was taken Sept. 13, 1966, about 160 miles over the Atlantic Ocean. The tether was later used in an experiment to test the feasibility of creating artificial gravity. Photo credit: NASA



For 26 seconds the Agena engine fired, boosting Gemini XI to 850 miles above the Earth, breaking the 475-mile altitude record set in July 1966 by Gemini X.

"Whoop-dee-do," Conrad exclaimed as the Agena engine shut down.

Gordon was equally excited in his remarks to capcom Young, who had been command pilot on Gemini X.

"I agree with you, John," Gordon said, "riding that PPS is the biggest thrill we've had all day."

For the next three-and-a-half hours Conrad and Gordon described the view from this unprecedented vantage point.

"It really is blue," Conrad said. "That water really stands out and everything looks blue. Obviously, the curvature of the Earth stands out a lot."

"Sounds like you're really way up there," Young responded from Mission Control.

As Gemini XI continued on its 26th orbit, Conrad and Gordon reached the 850-mile apogee over the southern hemisphere.

"We're looking straight down over Australia now," Conrad said.

"We have the whole southern part of the world out one window. Utterly fantastic."

After a little more than two orbits at the higher altitude, the Agena PPS engine was fired again, lowering their orbit to 188 miles.

On flight day three, Gordon was slated to perform another spacewalk. Actually, it was more of a "space stand-up." He positioned himself in the open hatch, standing on the spacecraft floor for two hours and eight minutes to photograph the Earth, clouds and stars. During that time, Conrad was maneuvering the spacecraft, pointing Gordon and his camera in the desired direction.

Shortly after the stand-up spacewalk, it was time to undock from the Agena and try out the "passive attitude stabilization" experiment.

"We're going to hate to leave this Agena," said Gordon as they undocked from their rendezvous target over Hawaii. "It's been kind to us."

Gemini XI separated from the Agena with their spacecraft pointed nose-down toward the Earth. Conrad and Gordon maneuvered their craft to keep the tether taut between both. By



Charles "Pete" Conrad climbs from Gemini XI minutes after splashdown. Following a computer-controlled re-entry Sept. 15, 1966, the spacecraft landed only 1.5 miles from the planned position in the Atlantic Ocean. A helicopter from the USS Guam picked up Conrad and Dick Gordon, taking the astronauts to the recovery ship. Photo credit: NASA

firing their side thrusters to slowly rotate the combined spacecraft, they were able to use centrifugal force to generate about 0.00015 g. "There is an artificial gravity field," Gordon said. "It makes the camera move back very rapidly."

The tether was released following two orbits of the artificial gravity experiment, allowing Gemini and Agena to go their separate ways.

The following day, Sept. 15, 1966, Gemini XI would become the first U.S. spacecraft to demonstrate a computer-controlled landing. Gemini XI's retro rockets were automatically fired on the 44th orbit with the onboard computer performing the needed re-entry maneuvers.

The command pilots of earlier Gemini flights took the controls at about 75 miles up, using the spacecraft's offset center of gravity to generate lift for changes in direction. For Gemini XI, the spacecraft automatically followed the computer commands.

It worked well, with Gemini XI splashing down only 1.5 miles from the planned position in the Atlantic Ocean near its recovery ship, the USS Guam.

As NASA officials looked ahead to the final mission before the start of Apollo, spacewalking — also known in the agency's vernacular as extravehicular activity — remained an unconquered challenge.

After Gemini XI, Manned Spacecraft Center Director Robert Gilruth stated, "Extravehicular activity (is) a primary objective of Gemini XII."

*EDITOR'S NOTE: This is the eighth in a series of feature articles marking the 50th anniversary of Project Gemini. The program was designed as a steppingstone toward landing on the moon. The investment also provided technology now used in NASA's work aboard the International Space Station and planning for the Journey to Mars. In November, read about solving the problems with spacewalking. For more, see "On the Shoulders of Titans: A History of Project Gemini."*





An RL10 engine stands in a vacuum chamber at Aerojet Rocketdyne's test stand in West Palm Beach, Florida. The engine will be one of two used for the Centaur upper stage during a United Launch Alliance Atlas V mission to launch Boeing's CST-100 Starliner on a flight test carrying a crew. The engine was test-fired as part of acceptance testing to confirm the engine is ready for flight. Photo credit: NASA/Dimitri Gerondidakis

National Aeronautics and Space Administration

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