June 2019 Vol. 6 No. 5

National Aeronautics and Space Administration

NASA

KENNEDY SPACE CENTER'S

SPACEPORT magazine

Team practices crew rescue at sea

KENNEDY SPACE CENTER'S

SPACEPORT MAGAZINE

CONTENTS

For the latest on upcoming launches, check out NASA's Launches and Landings Schedule at

www.nasa.gov/launchschedule.

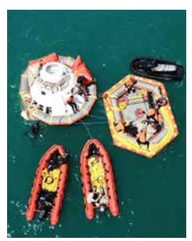
Want to see a launch?

The Kennedy Space Center Visitor Complex offers the closest public viewing of launches from Kennedy Space Center and Cape Canaveral Air Force Station. Launch Transportation Tickets are available for some, but not all, of these launches. ***Call 321-449-4444 for information on purchasing tickets.***

When will the International Space Station fly over you?

Find out and sign up for alerts at

spotthestation.nasa.gov



In this photograph from above, rescue team members use a Boeing CST-100 Starliner training capsule to rehearse a search and rescue training exercise in the unlikely event of an emergency resulting in a splashdown. NASA and the Department of Defense Human Space Flight Support Office Rescue Division conducted the open-ocean exercise. Photo credit: NASA/Isaac Hutson

Kennedy Space Center has its own monthly podcast. Welcome to the "Rocket Ranch." Listen to **Episode 10: Gateway**. NASA's latest exploration goals center on returning humans to the Moon – not just for a visit, but to stay. At the center of that plan is Gateway. It's a small lunar outpost that will have living quarters, laboratories for science and research, docking ports for visiting spacecraft, and more. Check out Episode 10: Gateway, read the full transcript and catch up on missed episodes at https://www.nasa.gov/kennedy/rocketranch.

To get the latest Kennedy Space Center updates, follow us on our Blog, Flickr, Facebook and Twitter.

KSC BLOG

THE SPACEPORT MAGAZINE TEAM

Editorial

Editor..... Linda Herridge
Asst. Editor ..... Anna Heiney

Writers Group

Jim Cawley, Linda Herridge, Anna Heiney, Danielle Sempsrott

Creative Group

Amy Lombardo, Cassandra White, Richard Murrey, Matthew Young

I am KENNEDY

SPACE CENTER

TAMIKO FLETCHER

I am Kennedy Space Center's chief information security officer (CISO) and chief of the center's IT Security Office. In my role as the CISO, I am responsible for reporting IT security threats to the center Chief Information Officer and NASA's Senior Agency Information Security Officer to minimize the center's IT security risk, obtain visibility into IT security operations across the center, and provide guidance for compliance with NASA's IT security standards and federal regulations.

I've been at Kennedy for 18 years, starting as a Cooperative Education Student. In December 2018, I was selected for my current position.

The biggest challenge in this job is increasing the center's awareness, understanding and adherence to IT security requirements. There's an increasing threat to our work in space exploration, and the IT Security Office is responsible for ensuring Kennedy's missions, projects and partners can identify potential security risks, assess them and develop a mitigation strategy that still enables mission success.

I am a graduate of the University of South Carolina with a bachelor's degree in computer engineering, and of the University of Miami with a master's in industrial engineering. I've served in a number of roles at Kennedy, including deputy CISO for Operations and lead of the IT security vulnerability management team. I served a detail assignment with the Office of the Administrator under the leadership of former NASA Administrator Charlie Bolden.

My favorite memory at Kennedy was sitting in what is called a "bunny suit" in the cockpit of space shuttle Discovery as a student. Now, I'm able to see the design of Artemis 1, assist with requirements for the Lunar Gateway and hear about other exploration missions. I'm excited about what's next in space exploration. I look forward to understanding these technologies so IT security can protect NASA's data and systems.

Rehearsal at Sea

Commercial Crew rescue training ramps up

BY TORI MCLENDON

Two NASA astronauts recently completed a crew rescue training exercise several miles off the coast of Cape Canaveral near NASA's Kennedy Space Center in Florida. NASA astronaut **Suni Williams** sat in a spacecraft as it bobbed in open seas surrounded by NASA and Department of Defense (DoD) watercraft monitoring her progress as she rehearsed the steps astronauts would take to exit Boeing's CST-100 Starliner spacecraft without assistance in the unlikely case of an abort.

"You never know where this job might take you," Williams said. "You might not expect to find an astronaut in the ocean, but this is an essential part of our training. If we ever need to actually do this, we don't want to be figuring it out in real time."

Williams, who is assigned to the second crewed Starliner flight, was joined by NASA astronaut **Barry "Butch" Wilmore** for the emergency training rehearsal. Wilmore is the backup crew member for both the first and second crewed Starliner flights. Although Starliner is designed to land in the desert, it must also be able to land in the water in an emergency, and its crew must be prepared for all possibilities.

In this case, that preparation required Williams and Wilmore to open the Intravehicular Activity (IVA) hatch on top of the spacecraft, which is used to dock to the **International Space Station**. They then rehearsed unloading a rescue raft from inside the spacecraft, climbing out through the open hatch, jumping into the Atlantic Ocean and boarding the raft.

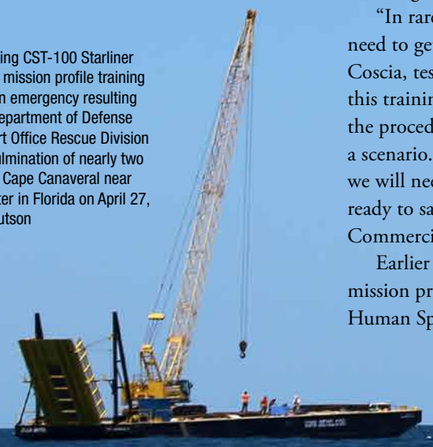
"In rare emergency situations, astronauts would need to get out of the capsule on their own," said Erin Coscia, test lead from Johnson Space Center. "During this training exercise, Williams and Wilmore rehearsed the procedures that they would need to follow in such a scenario. Now we understand the improvements that we will need to make with the crew to ensure that we are ready to safely return human spaceflight launches with the Commercial Crew Program."

Earlier the same day, the astronauts observed the full mission profile training exercise, conducted by the DoD Human Space Flight Support (HSFS) Office Rescue Division. This exercise, which was a culmination of nearly two weeks of **training**, included locating a Starliner mockup spacecraft using a portable Search and Rescue Satellite Aided Tracking (SARSAT) beacon like those used on boats and aircraft, which was detected by a portable version of the Lightweight Airborne Recovery System, onboard a C-17 aircraft to locate and communicate with astronauts in an emergency situation. Next, nine U.S. Air Force "Guardian Angel" Pararescue forces were airdropped from the C-17 with their specialized watercraft, rescue equipment and medical supplies. The team rehearsed assisted egress, extracting DoD team members acting as astronauts, from the capsule and providing immediate medical treatment.

"Our crew members have an essential job to do on the International Space Station. It is our responsibility to safely get the crew to and from the orbiting laboratory," said Kathy Lueders, manager of NASA's Commercial Crew Program. "I think about our work with the Human Space Flight Support Office as insurance. I hope we never need their services, but it is essential that they are prepared if we ever need to call them in."

The HSFS rescue division coordinates contingency support for the nation's human spaceflight program. This integrated team has supported all NASA human spaceflight missions throughout the last 60 years. HSFS will be on standby for commercial crew missions. In the unlikely event of an emergency during ascent, free flight or landing, the HSFS teams will quickly and safely rescue our astronauts. The HSFS office also will support all **Orion**/SLS launches and landings. These DoD teams undergo countless hours of training to prepare for a variety of scenarios. It is standard practice to conduct these exercises, and was regularly done during the **Space Shuttle Program**.

Last year, HSFS conducted two **similar exercises** with SpaceX's Crew Dragon spacecraft mockup. This simulation is another example of how safety is being built into systems, processes and procedures for commercial crew missions.



Rescue team members use a Boeing CST-100 Starliner training capsule to rehearse a full mission profile training exercise in the unlikely event of an emergency resulting in a splashdown. NASA and the Department of Defense (DoD) Human Space Flight Support Office Rescue Division conducted the exercise, after a culmination of nearly two weeks of training, off the coast of Cape Canaveral near the agency's Kennedy Space Center in Florida on April 27, 2019. Photo credit: NASA/Isaac Hutson

NASA astronaut Barry "Butch" Wilmore, at left, rehearses the steps he would take to exit Boeing's CST-100 Starliner spacecraft without assistance in the unlikely event of an emergency resulting in a splashdown. The training exercise, which occurred April 27, 2019, took place several miles off the coast of Cape Canaveral near NASA's Kennedy Space Center. Photo credit: NASA/Michael Downs

NASA astronaut Suni Williams, at left, rehearses the steps she would take to exit Boeing's CST-100 Starliner spacecraft without assistance in the unlikely event of an emergency result in a splashdown on April 27, 2019 off the coast of Cape Canaveral near NASA's Kennedy Space Center. Photo credit: NASA/Michael Downs

Boeing completes Starliner hot fire test

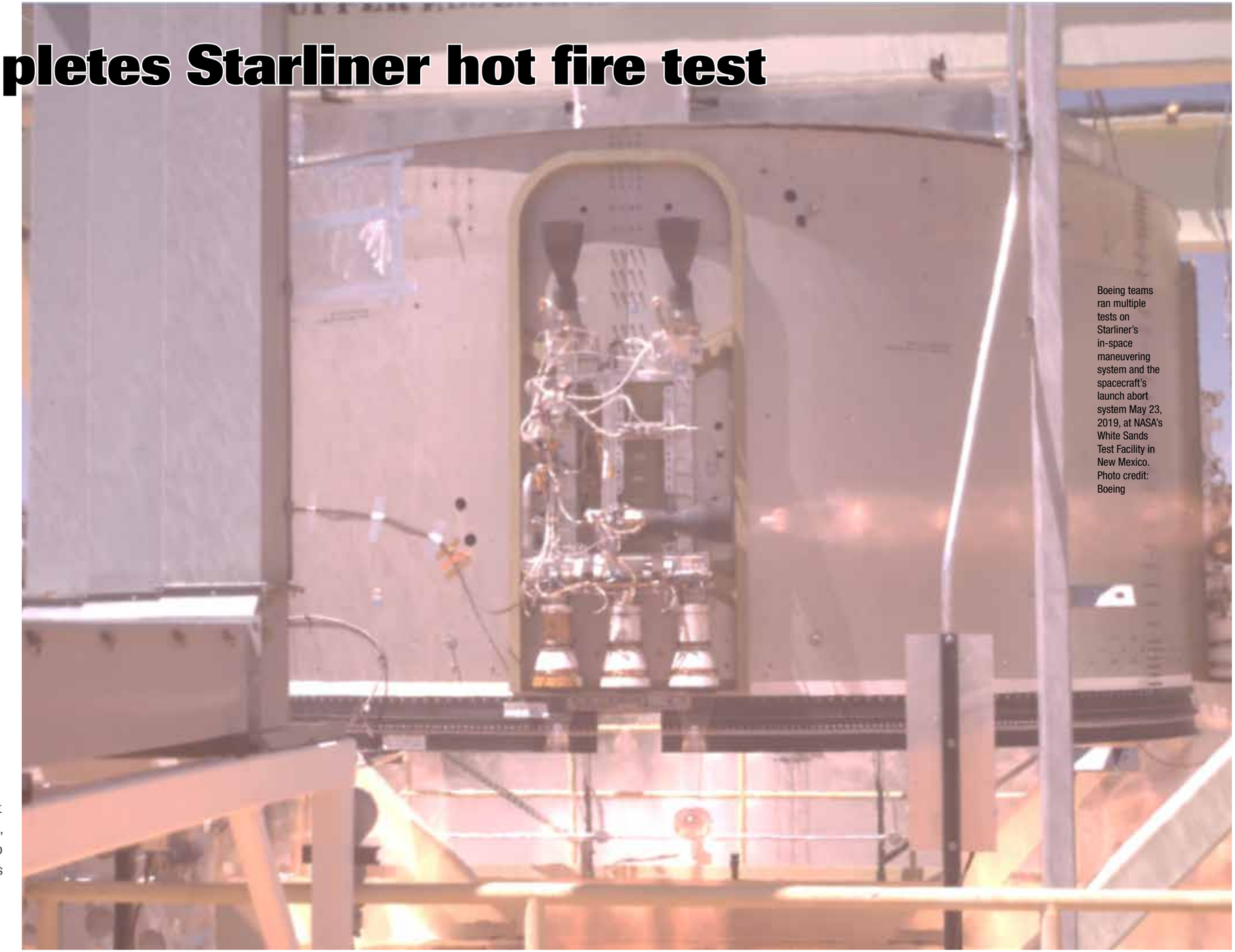
Boeing's CST-100 Starliner propulsion system was put to the test on May 23, 2019, at NASA's White Sands Test Facility in New Mexico, in support of NASA's Commercial Crew Program. Teams ran multiple tests on Starliner's in-space maneuvering system and the spacecraft's launch abort system, which are key elements on the path to restore America's capability to fly astronauts to the International Space Station on American rockets and spacecraft from U.S. soil.

The test used a flight-like Starliner service module with a full propulsion system comprising fuel and helium tanks, reaction control system and orbital maneuvering and attitude control thrusters, launch abort engines and all necessary fuel lines and avionics.

During the test:

- 19 thrusters fired to simulate in-space maneuvers.
- 12 thrusters fired to simulate a high-altitude abort.
- 22 propulsion elements, including the launch abort engines, fired to simulate a low-altitude abort.

Boeing's Starliner will launch on a United Launch Alliance Atlas V rocket from Space Launch Complex-41 at Cape Canaveral Air Force Station in Florida. The company will complete a Starliner pad abort test and uncrewed flight test, called Orbital Flight Test, to the station ahead of the first flight test with a crew onboard. As commercial crew providers, Boeing and SpaceX, begin to make regular flights to the space station, NASA will continue to advance its mission to go beyond low-Earth orbit and establish a human presence on the Moon with the ultimate goal of sending astronauts to Mars.



Boeing teams ran multiple tests on Starliner's in-space maneuvering system and the spacecraft's launch abort system May 23, 2019, at NASA's White Sands Test Facility in New Mexico. Photo credit: Boeing

Atlas V rocket for Starliner crew missions to station arrives

The United Launch Alliance (ULA) Atlas V booster that will be used for Boeing's Crew Flight Test (CFT) is backed into the Atlas Spaceflight Operations Center (ASOC) at Cape Canaveral Air Force Station in Florida on June 5, 2019. The ULA Atlas V rocket will launch Starliner and its crew to the International Space Station for NASA's Commercial Crew Program. Inside the ASOC, the booster will await the start of operations for its missions. The CFT will demonstrate Starliner and Atlas V's ability to safely carry crew to and from the orbiting laboratory. Photo credit: NASA/Frank Michaux

The United Launch Alliance (ULA) Atlas V rocket that will launch Boeing's CST-100 Starliner spacecraft on its Crew Flight Test (CFT) to the **International Space Station** for NASA's **Commercial Crew Program** arrived on Saturday at Cape Canaveral Force Station in Florida.

The booster stage and the Dual Engine Centaur upper stage of the Atlas V rocket, designated AV-082, arrived on ULA's Mariner cargo ship from the company's facility in Decatur, Alabama.

The Atlas V rocket, now located in the company's Atlas Spaceflight Operations Center at Cape Canaveral, will undergo receiving checks and await the start of operations for its mission. The CFT mission will take NASA astronauts **Mike Fincke** and **Nicole Mann**, and Boeing astronaut **Chris Ferguson** to the station to demonstrate Starliner and Atlas V's ability to safely carry crew to and from the orbiting laboratory.

CFT will be the second Starliner flight following the uncrewed Orbital Flight Test (OFT) that is targeted to launch to the station in August. The rocket for OFT, called AV-080, was brought to the Cape last year.

Both flights are key elements of NASA's Commercial Crew Program that will return the nation's capability to launch astronauts into orbit on American rockets and spacecraft from U.S. soil. Regular commercial transportation using Boeing's Starliner and SpaceX's Crew Dragon spacecraft to and from the space station will enable the addition of another crew member, expanded station use, and additional research time aboard the orbiting laboratory. This time will help address the challenges of moving humanity toward the Moon and Mars as we learn how to keep astronauts healthy during long-duration space travel and demonstrate technologies for human and robotic exploration beyond low-Earth orbit, to the Moon and Mars.

The test version of Orion attached to the Launch Abort System for the Ascent Abort-2 (AA-2) flight test exits the Launch Abort System Facility at NASA's Kennedy Space Center in Florida on May 22, 2019. The flight test article will make the 21.5 mile trek to Space Launch Complex 46 at Cape Canaveral Air Force Station. The launch is planned for July 2 and is a critical safety test that helps pave the way for Artemis missions near the Moon, and will enable astronauts to set foot on the lunar surface by 2024. Photo credit: NASA/Frank Michaux

TEAMWORK

Exploration Ground Systems assists with Ascent Abort-2 preparations

BY ANNA HEINEY

NASA is gearing up for a test of the system that will help keep astronauts safe when traveling to the Moon aboard agency's Orion spacecraft. The Ascent Abort-2 (AA-2) flight test will put Orion's launch abort system (LAS) to work in a high-flying, fast-paced trial without crew aboard.

The test paves the way for Artemis 2, the first flight of astronauts aboard Orion and the powerful new Space Launch System (SLS) rocket on a mission to carry humans around the Moon for the first time in half a century. Following Artemis 2, NASA will send the first woman and next man to step foot on the Moon in 2024. For NASA's Exploration Ground Systems (EGS) and Jacobs Test and Operations Contract (TOSC) teams, preparations for AA-2 also have provided invaluable opportunities to prepare for Artemis 1, the uncrewed first flight of SLS and Orion.

"AA-2 is really a 'first-flow' mission," said Sean Arrieta, NASA EGS element operations manager in the Launch Abort System Facility (LASF), where the Orion crew module flight test article was integrated with the protective payload fairing and launch abort tower. This process marked the first time both elements were prepared using the same sequence and procedures that will be used going forward, providing valuable experience for the team.

The entire test will last about three minutes, but the teamwork and lessons honed during the months leading up to it will benefit Artemis missions for years to come.

Currently slated for July 2, the AA-2 flight test will lift off from Space Launch Complex 46 at Florida's Cape Canaveral Air Force Station atop an abort test booster provided by Northrop Grumman. The booster will send a test version of the Orion spacecraft with the launch abort system to an altitude of about six miles traveling at more than 1,000 miles per hour. The abort motor will quickly whisk the crew module away from the booster, and the attitude control motor will maneuver the assembly into position to jettison the crew module.

Over the past several months, teams have been working to perfect the many processes, procedures and handoffs the combined team will use for both AA-2 and the first Artemis mission.

"We tried to plan the work as we would for future missions," said mechanical engineer Alex Mire. She's led TOSC's AA-2 operations inside the LASF, determining scheduling, drawing, requirements reviews and more. Mire pointed out that much of the AA-2 hardware is so similar to Artemis 1 or Artemis 2 that there's only a letter difference in the part numbers. "We've made a lot of updates to our procedures, which should help the processing flow go smoothly."

Several organizations have been involved in getting AA-2 off the ground, and with so many groups handling a variety of elements, one big challenge facing EGS/TOSC was navigating the differences to ensure that hardware and human teams were working well together.

Inside the Launch Abort System Facility at NASA's Kennedy Space Center, workers complete the integration of a test version of the Orion crew module with the Launch Abort System on May 18, 2019. Photo credit: NASA/Frank Michaux

"All these different entities had their own processes and cultures, and many of them had never been to Kennedy," said Jim Bolton, EGS AA-2 operations lead. "It sounds easy: 'Here's a hangar, do your work.' But it's not as simple as that."

Lockheed Martin built the launch abort system inside the LASF, then handed off to the EGS/TOSC team in place at the facility. That team brought the crew module and separation ring to the facility and handled all the integration. The same process will be followed for all future Artemis missions with Orion.

According to Arrieta, this arrangement has allowed EGS to work very closely with contractor teammates.

"It allows for better integration of information," he said. "It's good for the health of the combined team and has led to a high level of trust."

The Orion LAS rolled out of the LASF around 6 p.m. on May 22 for the more than nine-hour trek to the launch pad, and it was later hoisted into position atop the waiting abort test booster. Meanwhile, in the LASF, the processing flow for Artemis 1 can begin.

"AA-2 shows this workforce and the nation that we're on the precipice of doing what Kennedy Space Center was built to do: processing and launching spaceflight hardware," Arrieta said. "It's a foundation, a concrete stepping stone our program can stand on and say, 'Look at what we've accomplished—and where we're about to go.'"

Integration and Checkout

The flight test article for Orion's Ascent Abort-2 (AA-2) flight test passes by the Vehicle Assembly Building at NASA's Kennedy Space Center on its 21.5-mile-trek to Space Launch Complex 46 at Cape Canaveral Air Force Station on May 22, 2019. Photo credit: NASA/Frank Michaux

Orion Flight Test Article Attached to Launch Abort System for Ascent Abort-2

BY LINDA HERRIDGE

The 46,000-pound flight test article that will be used for a test of Orion's Launch Abort System (LAS) was lifted and mated to its transportation pallet inside the Launch Abort System Facility at NASA's Kennedy Space Center on May 18, 2019. The flight test article includes the Orion test article, a separation ring created for this test, and the LAS. This operation marks the completion of the flight test article integration and checkout operations necessary for NASA's **Ascent Abort-2** (AA-2) flight test scheduled for July. Next, the system will roll to Pad 46 where the team will be stacking all the AA-2 elements together at the launch pad over the next several weeks.

AA-2 will demonstrate the abort system can activate, steer the spacecraft, and carry astronauts to a safe distance if an emergency arises during Orion's climb to orbit as the spacecraft faces the greatest aerodynamic pressure during ascent. AA-2 is an important test to verify Orion's design to safely carry astronauts on deep space missions as NASA works to land the first woman and next man on the **Moon by 2024**

During the three-minute **test**, the LAS with the Orion test article will launch atop a booster from Space Launch Complex 46 at Cape Canaveral Air Force Station, to an altitude of about six miles and traveling at more than 1,000 mph. The abort motor will quickly whisk the crew module away from the booster, and the attitude control motor will maneuver the assembly into position to jettison the crew module. Test data from 890 **sensors** will be sent in real-time to ground sites as well as recorded on board by 12 data recorders. The 12 data recorders will eject from the crew module before Orion reaches the water and will be **retrieved** after the test.

With no astronauts on board, the test concludes after the data recorders are ejected and does not include parachutes or recovery of the test capsule. AA-2 is focused on testing Orion's ability to abort during ascent, and NASA has already fully qualified the parachute system for flights with crew through an extensive series of 17 developmental tests and 8 qualification tests **completed** at the end of 2018.

The LAS was designed and built by NASA and Lockheed Martin with motors provided by Northrop Grumman and Aerojet Rocketdyne. NASA's Orion and Exploration Ground Systems programs, contractors Jacob's, Lockheed Martin and Northrop Grumman, in conjunction with the Air Force Space and Missile Center's Launch Operations branch and the 45th Space Wing will perform flight operations for AA-2.

On A Roll!

Flight Test Article Moves to Launch Pad 46

Engineers rolled a test version of the Orion spacecraft integrated with the Launch Abort System for the **Ascent Abort-2** flight test from Kennedy Space Center's Launch Abort System Facility to Space Launch Complex 46 at Cape Canaveral Air Force Station in preparation for its launch this summer.

The 21.5 mile trek began around 6 p.m. on May 22, and finished at 3:18 a.m. on May 23. The team will be stacking all the AA-2 elements together at the launch pad over the next several weeks.

During the **flight**, planned for July 2, a test version of Orion will launch on a booster to more than six miles in altitude, where Orion's launch abort system will pull the capsule and its crew away to safety if an emergency occurs during ascent on the **Space Launch System** rocket.

The test helps pave the way for **Artemis** missions at the Moon and will enable astronauts to set foot on the lunar surface by 2024.

Above: A test version of the Orion crew module was integrated with the Launch Abort System on May 18, 2019. It was then lifted by crane for transfer to a KAMAG transporter. Photo credit: NASA/Glenn Benson

Left: The test version of Orion attached to the Launch Abort System for the Ascent Abort-2 (AA-2) flight test is moved by crane into the vertical integration facility at Space Launch Complex 46 at Cape Canaveral Air Force Station in Florida on May 23, 2019. The flight test article will be stacked atop the booster, which was procured by the U.S. Air Force and manufactured by Northrop Grumman. Photo credit: NASA/Tony Gray

Surround Sound

Orion Service Module for Artemis 1 Undergoes Acoustic Tests

Orion's service module for NASA's Artemis 1 mission recently completed acoustic testing inside the Operations and Checkout Building at NASA's Kennedy Space Center in Florida. The tests were the latest step in preparing for the agency's first uncrewed flight test of Orion on the Space Launch System (SLS) rocket.

Teams completed the test May 25, 2019, and technicians will analyze the data collected during the tests to check for flaws uncovered by the acoustic environment. During the testing, engineers secured the service module inside the test cell and then attached microphones, strain gauges and accelerometers to it. They conducted a series of five tests, with acoustic levels ranging from 128 to 140 decibels – as loud as a jet engine during takeoff.

Artemis 1 will be the first mission launching Orion on the SLS rocket from Kennedy's Launch Pad 39B. The mission will take Orion thousands of miles past the Moon on an approximately three-week test flight. Orion will return to Earth and splashdown in the Pacific Ocean off the coast of California, where it will be retrieved and returned to Kennedy.

Orion's service module for NASA's Artemis 1 mission was moved from a test stand to a test cell inside the Operations and Checkout Building at the agency's Kennedy Space Center on May 22, 2019. Photo credit: NASA/Frank Michaux

Mission Focus

Orion window testing brings Artemis 1 closer into view

BY JIM CAWLEY

The first **Artemis** mission may not have astronauts to peer through the windows of NASA's Orion spacecraft as it makes its trip around the Moon, but the agency will share those views with the world. Orion's windows for the upcoming flight have recently undergone stringent evaluation and assessment to ensure optimal optical performance, and are just one test away from receiving final approval for the mission.

"Everything for Artemis 1 windows testing is nearly complete," said Susan Danley, a windows engineer who has worked at the agency's Kennedy Space Center in Florida for 15 years. "The final step in evaluating the windows is vibration testing, which will be completed in the coming months as part of the structural/pressure testing."

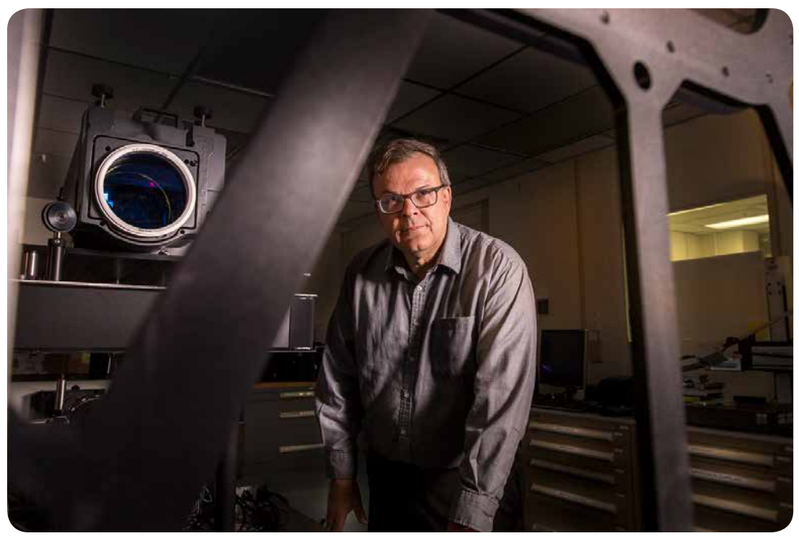
The process received a significant boost with the recent completion of optical verification testing, performed by Mark Nurge, Ph.D., a physicist in Kennedy's Applied Physics Lab. Each **window** has three panes: a fused silica thermal pane, an acrylic pressure pane and a redundant pane. Nurge examined all 19 windows for the spacecraft, including the launch abort system, individually and in their stacked configuration.

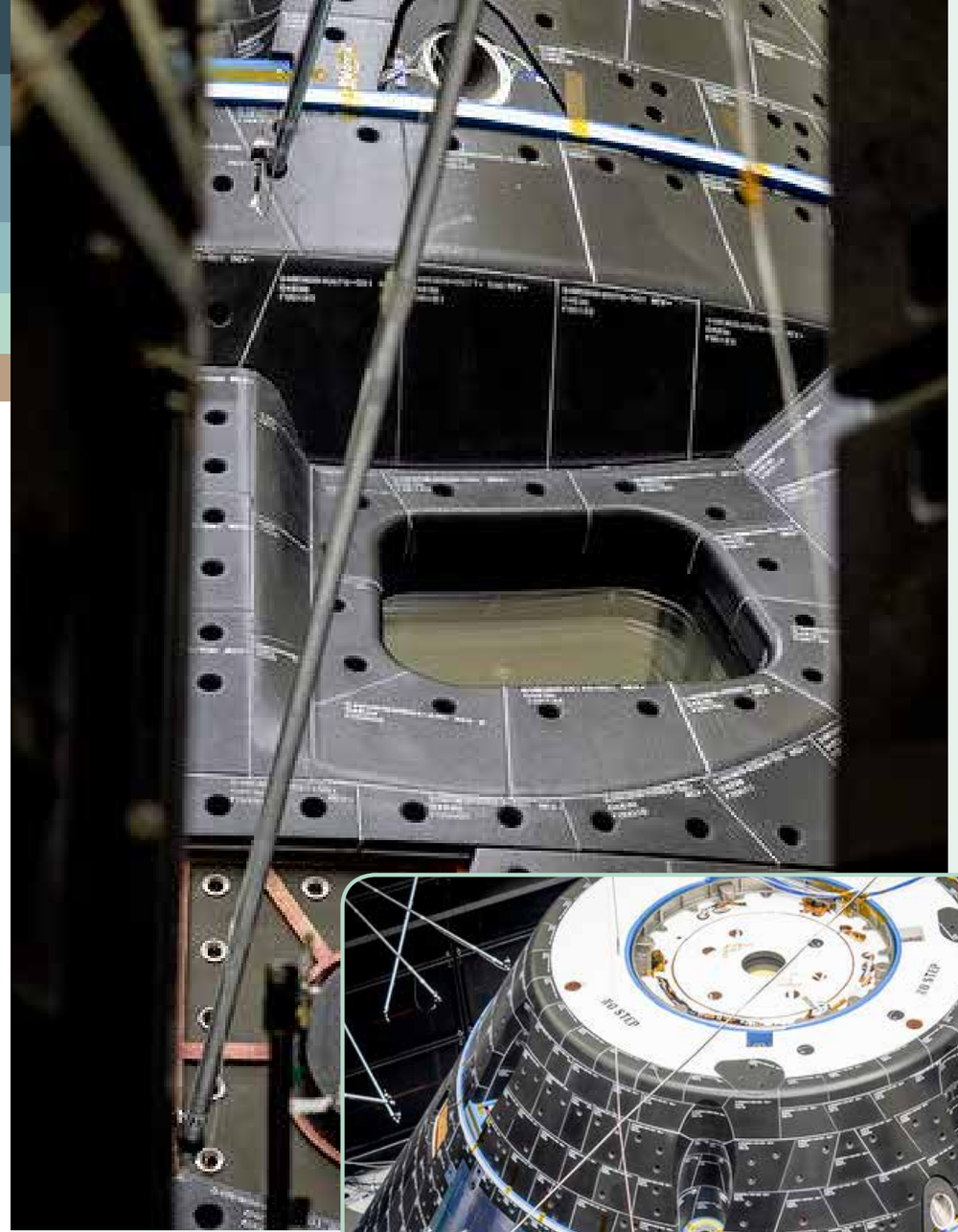
Nurge's testing and evaluation of Orion's windows involved the use of a laser interferometer, which is able to determine — with extreme precision — the level of distortion and imperfection to ensure high quality optical performance. An interferometer works by merging two or more sources of light to make precise measurements of an interference pattern; hence 'interfere-meter.' Engineers shoot a red laser through a 6-inch diameter region of the window; that laser bounces off a mirror behind the window and is processed by the interferometer.

Data from the interferometer is used to measure variations and thickness across the windows, along with transmission, which looks at the overall amount of light passing through the window. Nurge also evaluated color balance, haze and the quality of light as it passes through the window.

"These procedures will be performed for each mission to ensure the windows provide the optical performance required, not only for this uncrewed mission, but also for future astronauts as NASA sends the next man and first woman to land on the Moon," Nurge said.

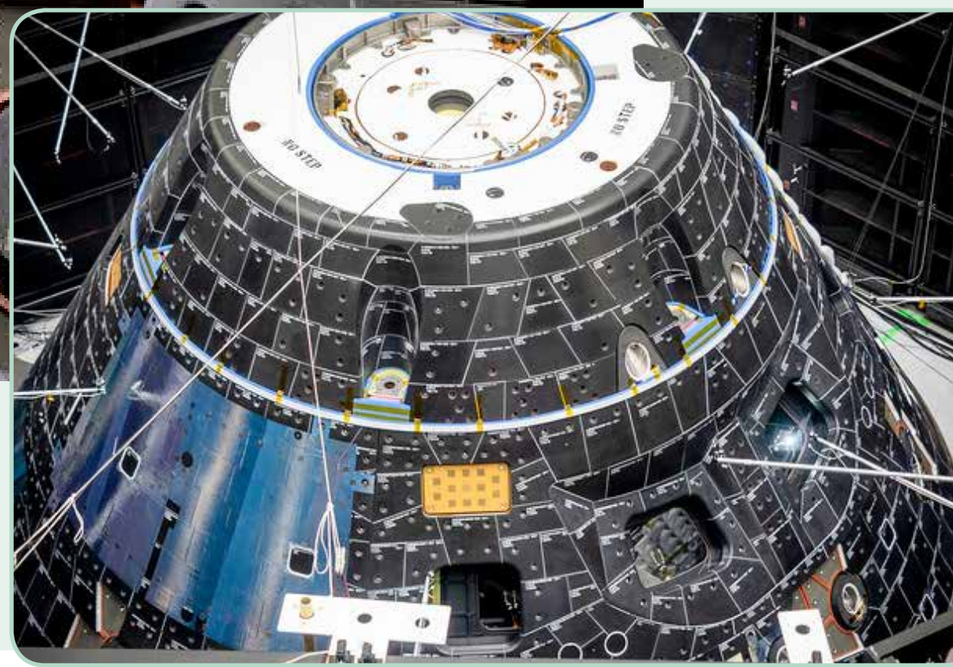
Artemis 1 will be the first flight test of NASA's Space Launch System rocket and uncrewed Orion spacecraft as an integrated system. It is the first in a series of increasingly complex missions that will land astronauts on the Moon by 2024, establish a sustainable presence, and enable human exploration to Mars.





Left: The Orion crew module for Artemis 1 recently completed windows testing where engineers used a laser interferometer to determine — with extreme precision — the level of distortion and imperfection to ensure high quality optical performance. Photo credit: NASA/Rad Sinyak

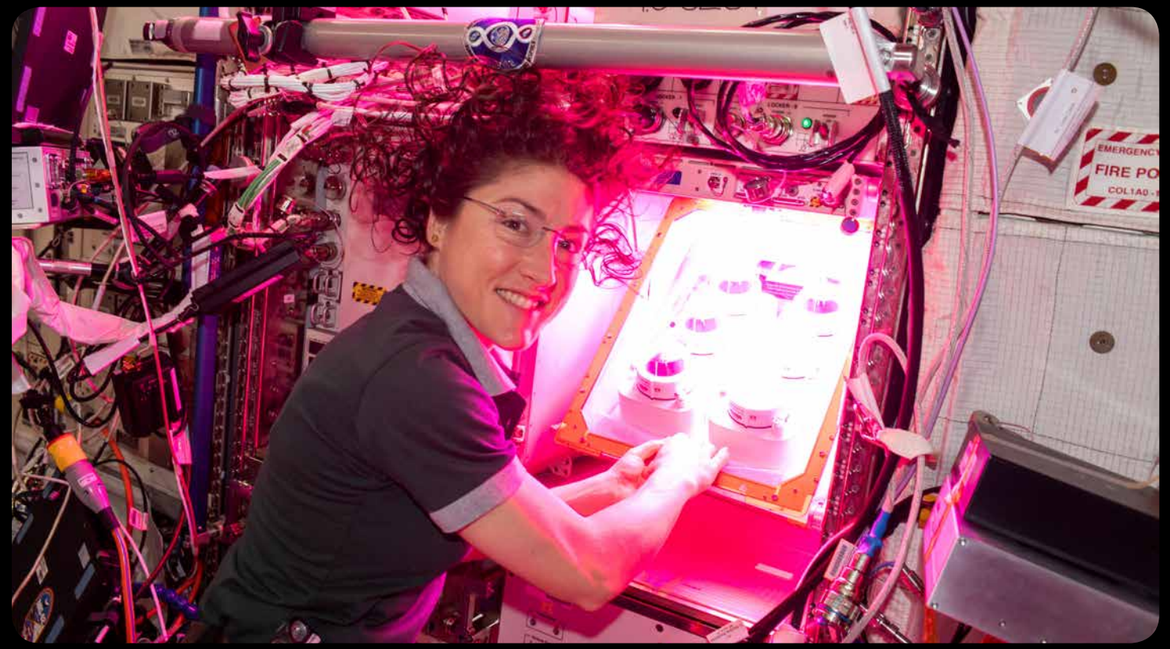
Below: Artemis 1 will be the first flight test of NASA's Space Launch System rocket and uncrewed Orion spacecraft as an integrated system. It is the first in a series of increasingly complex missions that will land astronauts on the Moon by 2024, establish a sustainable presence, and enable human exploration to Mars. Photo credit: NASA/Rad Sinyak



Left: Mark Nurge, a physicist in Kennedy Space Center's Applied Physics Lab, stands near a laser interferometer, which is used to determine if there are acceptable levels of distortion and imperfections in windows. Nurge recently completed optical metrology testing and evaluation of all flight windows on the Orion capsule for Artemis 1. Photo credit: NASA/Cory Huston

Expanding Crops

NASA testing method to grow bigger plants in space



NASA astronaut Christina Koch initiates the Veg-PONDS-02 experiment on the International Space Station within Veggie by filling the upper reservoir on April 25, 2019. Photo credit: NASA/David Saint-Jacques

BY DANIELLE SEMPSROTT

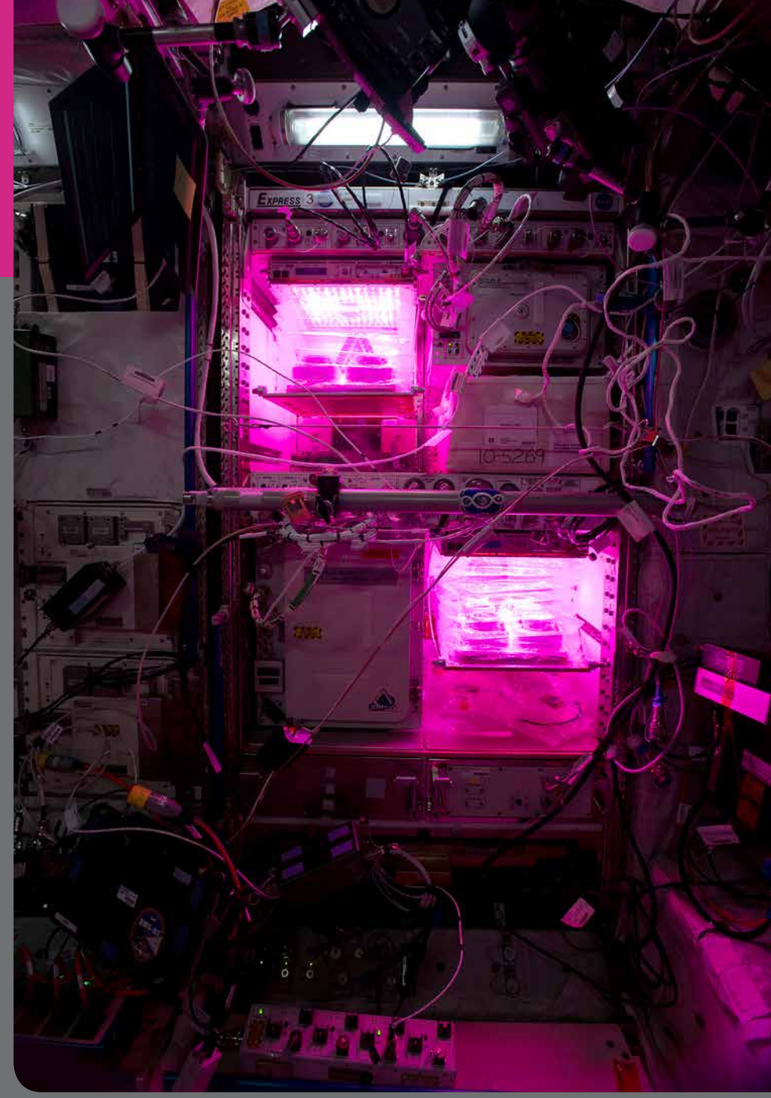
In an effort to increase the ability to provide astronauts nutrients on long-duration missions as the agency plans to sustainably return to the **Moon and move forward to Mars, the** Veg-PONDS-02 experiment is currently underway aboard the **International Space Station**.

The present method of **growing plants in space** uses seed bags, referred to as pillows, that astronauts push water into with a syringe. Using this method makes it difficult to grow certain types of "pick and eat" crops beyond lettuce varieties. Crops like tomatoes use a large amount of water, and pillows don't have enough holding capacity to support them.

As an alternative to the pillows, 12 passive orbital nutrient delivery system (**PONDS**) plant growth units are being put through their paces. The PONDS units are less expensive to produce, have more water holding capacity, provide a greater space for root growth and are a completely passive system—meaning PONDS can provide air and water to crops without extra power.

The 21-day experiment is a collaboration between NASA, Techshot, Inc., the Tupperware Brands Corporation, fluids experts at NASA's Glenn Research Center and Mark Weislogel at Portland State University. As a U.S. **National Laboratory**, the space station provides commercial companies and government agencies with the ability to test the experiment in a microgravity environment.

"There comes a point where you have longer and longer duration missions, and you reach a cost benefit point where it makes sense to grow your own food," said Howard Levine, chief scientist of NASA's Utilization and Life Sciences Office at the agency's Kennedy Space Center.



The Veg-PONDS-02 experiment sits in the International Space Station's two Veggie chambers. The 21-day experiment consisted of 12 plant growth units in three different design configurations available for testing. Photo credit: NASA/Christina Koch

After Levine developed the PONDS prototype, it was passed on to Dave Reed, Techshot's Florida operations director, and his team to re-engineer and make it capable of withstanding spaceflight. PONDS tested well on the ground, but when the system first arrived at the space station last year for testing in a microgravity environment, it pumped too much water to the lettuce seeds.

"We took a step back, evaluated different aspects of the design, and together with water fluid experts from NASA, we came up with three alternative designs, each of which had a number of components we wanted to test in space," said Levine.

On April 19, 2019, the Veg-PONDS-02 payload arrived at the orbiting laboratory via **Northrop Grumman's 11th Commercial Resupply mission**, containing 12 PONDS units in the three new design configurations. Six of the units have a clear design to allow researchers to observe the performance of water in the units during the experiment. All units contain red romaine lettuce seeds and have been placed in the two space station vegetable production systems, known as Veggie, to test growth performance.

NASA astronaut Christina Koch initiated the experiment by filling the upper reservoir on April 25. Canadian Space Agency (**CSA**) **astronaut David Saint-Jacques** filled the PONDS unit lower reservoir on May 2 and documented how water behaved in the system.

Reed and his team worked closely with material scientists and mechanical engineers with Tupperware to design and mold components that make up the PONDS-02 units.

"We needed something that was molded well, molded precisely and molded out of plastics that were compatible with edible material," said Reed. "They brought all this huge body of knowledge to us."

This experiment is a way to test the performance of the three alternative design methods in space to see if the water management issue initially discovered during the first PONDS experiment has been adequately addressed.

"I look at this as a normal part of the process," said David Brady, assistant program scientist in the International Space Station Program Science Office at NASA's Johnson Space Center. "You find what works and what doesn't work, and you adapt and change it. The fact that Howard and his team have been able to do that is progress."

On May 16, the final day of the experiment, the plants will be harvested. Six of the PONDS units will be returned to Earth on **SpaceX's 17th Commercial Resupply Services mission** for further analysis. Reed's team will take the successful components and combine them into one final PONDS design, which will pave the way for the agency to truly begin testing the growth capability of crop varieties beyond leafy greens.

"PONDS was an opportunity to do something that no one else has done before," said Reed. "People have been growing plants in space since the Apollo era, but not like this."

The Space Life and Physical Sciences Research and Applications Division (**SLPSRA**) of NASA's Human Exploration and Operations Mission Directorate at NASA Headquarters in Washington is sponsoring the Veg-PONDS-02 investigation as part of its mission to conduct research that enables human spaceflight exploration.

NASA's Kennedy Space Center Innovators' Launchpad:

Janine Captain

Principal investigator, Dr. Janine Captain, attaches a mass spectrometer sensor to electronics inside a vacuum chamber in the Space Station Processing Facility high bay at NASA's Kennedy Space Center on Dec. 12, 2018. The Mass Spectrometer observing lunar operations (MSolo) instrument is a commercial off-the-shelf mass instrument modified to work in space, and can identify molecules at lunar landing sites. These MSolo instruments are part of NASA's efforts to return to the Moon with the Commercial Lunar Payload Services Landers Program. Photo credit: NASA/Cory Huston

Please explain your job in a single sentence.

I am lucky enough to lead the science technical direction of an instrument that will measure volatile resources, like water that will readily turn to a liquid or gas, on the surface of the **Moon**.

What do you find most exciting about your job as the Mass Spectrometer observing lunar operations (MSolo) instrument principal investigator?

I love getting to work hands-on with the instrumentation and design and conduct experiments that will enable future exploration on the lunar surface.

What is a typical day like for you?

My days are very different. Some days are hands–on, working to install and checkout hardware, others are running experiments and collecting data to analyze; and, of course, I have some days filled with meetings and paperwork. The most typical thing I encounter is overcoming the challenges that pop up working in technology development.

Was the work you did your first month at NASA anything like your current work?

The project I am currently working on is something that I did work on my first month at NASA, but because of the technology advancement, it's a whole new world. The first steps toward this lunar resource demonstration started in 2005 when I was working for the science leads performing proof of concept testing in the lab. Now I'm leading the development of modified commercial instruments for flight, so I have seen the technology grow from **concept to flight**.

What is your educational background and why did you choose to study those areas?

My undergraduate degree is a double major in chemistry and marine science from the University of Miami. I started as a biology and marine science major because I wanted to talk to dolphins, but opportunities with some marine chemistry internships helped me realize I enjoyed working in the environmental chemistry area. I pursued a Ph.D. in chemistry from Georgia Tech, with my goal at the time of pursuing environmental atmospheric chemistry. Now my environment extends beyond the planet, but I use the same type of instrumentation to support exploration and technology development.

How do the era and place in which you grew up shape how you approach your work?

Working with older instruments really forced me to understand the settings and parameters used to optimize the analytical system. In my experience working with analytical instrumentation, there have been tremendous advances in technology that improve the instrumentation that we use. The automation of analysis can be beneficial; however, it can be dangerous to not truly learn the basic principles of the analysis and understand the parameters that can affect the data you collect.

What motivated you to want to work for NASA?

Honestly, I had never thought about pursuing a career at NASA. The opportunity came as I was applying for a postdoctoral position in environmental chemistry, and I jumped at the chance to learn where I could fit into the **NASA mission**.

Why does conducting research and developing new technology matter to you?

I enjoy the challenge of applied research and technology development. I think the focus on new technology that can improve our daily lives motivates me in a unique way because we can see the direct benefit of our work. The instruments that we develop can change the way we explore our solar system.

How do you think your NASA research or the agency as a whole benefits people on Earth?

Our collaborations are enabling commercial vendors to participate in exploration and improving products that can be used to **benefit the people on Earth**. These ruggedized instruments have been used in a wide variety of environmental monitoring applications that directly benefit the people of Earth. Research into hydrogen-sensing technology provides safety as we move toward using hydrogen as a fuel source.

Do you have any advice for people trying to foster innovation in the workplace?

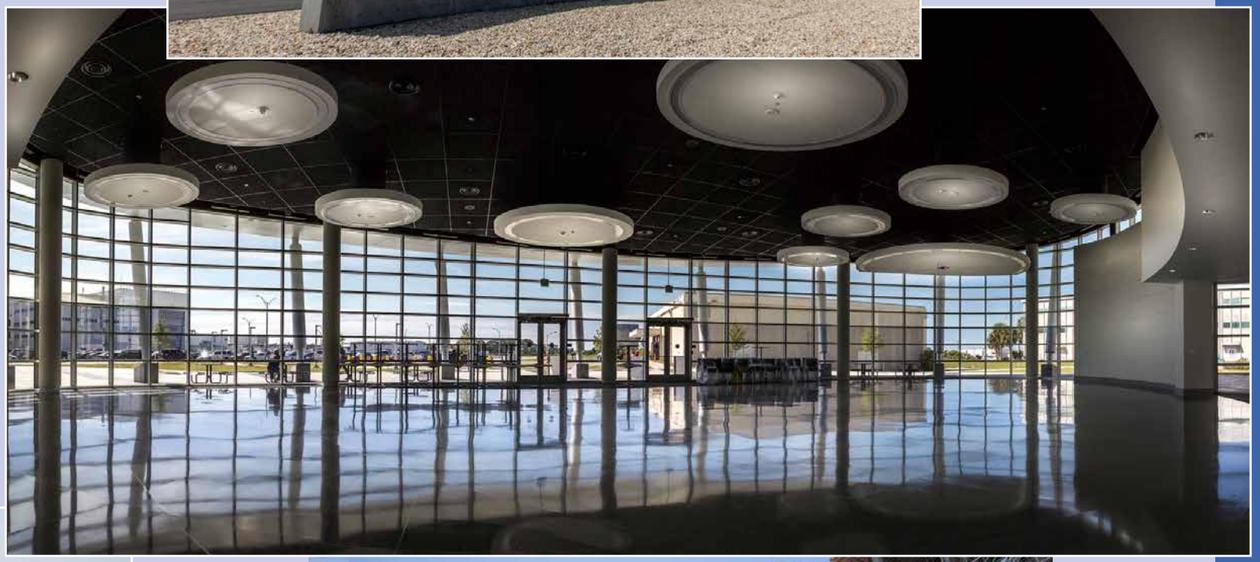
I think the most important aspect of a team that enables innovation is to have open and honest communication. Everyone needs to be able to build on ideas and ask questions to enable understanding and come up with unique solutions.

At the construction site for the new, modernized Central Campus Headquarters building at NASA's Kennedy Space Center, concrete pilings have been driven into the ground at varying depths as a test. A bulldozer is clearing the site on May 14, 2015 for more pilings to be added. In the background is the existing Headquarters Building. Photo credit: NASA

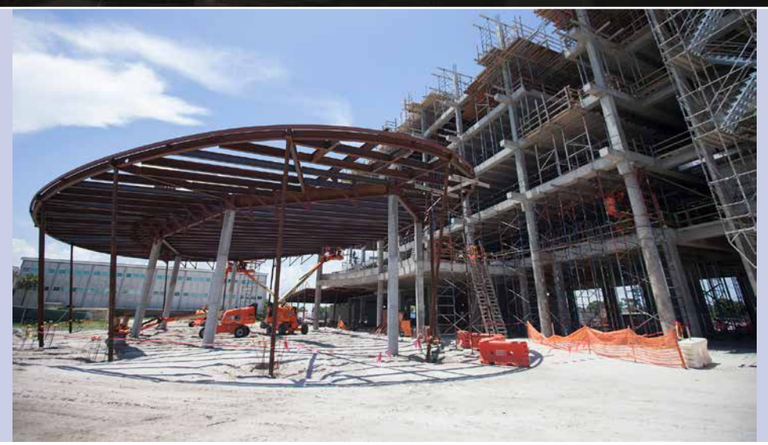
Left: A view of the completed Central Campus Headquarters building on April 3, 2019, at NASA's Kennedy Space Center. Photo credit: NASA/Cory Huston

Below: A view of the cafeteria area inside the Central Campus Headquarters building on April 3, 2019, at NASA's Kennedy Space Center. Photo credit: NASA/Cory Huston

One of the design elements in the lobby of the new Central Campus Headquarters building is a bust of President John F. Kennedy and some of his famous quotes. Photo credit: NASA/ Cory Huston



Left: Progress on the new Central Campus Headquarters building is seen during an aerial view of NASA's Kennedy Space Center on Oct. 8, 2016. Photo credit: NASA/Cory Huston



Left: Construction was in full swing on the new Central Campus Headquarters building on July 11, 2016 at NASA's Kennedy Space Center. Photo credit: NASA/Ben Smegelsky

New Central Campus Completed

Houses 500 civil service and contractor employees

The new Central Campus Headquarters building features:

- LED lighting throughout
- Occupancy sensors that turn lights on and off
- Florida native plants in landscaping
- North-facing windows take advantage of diffused sunlight coming into the facility
- South-facing windows feature a built-in wall screen and sunshades that limit direct sunlight
- Electric gearless traction elevators do not require a machine room
- Renewable energy from the KSC Photovoltaic Solar Farm provides energy to the facility
- Facility earned the **LEED** Gold Rating (Leadership in Energy and Environmental Design) from the U.S. Green Building Council

Each floor features an accent color scheme that represents a planet in our solar system:

First floor – Mercury
Second floor – Venus
Third floor – Mars
Fourth floor – Jupiter
Fifth floor – Saturn
Sixth floor – Uranus
Seventh floor – Neptune

- Constellations embedded in lobby flooring
- Solar system portrayed in cafeteria seating area flooring
- Cloud effects in the ceiling

NASA ADMINISTRATOR VISITS FLORIDA TECH

NASA Administrator Jim Bridenstine speaks to students, faculty, engineers and area business leaders at Florida Institute of Technology on May 23, 2019. Bridenstine delivered the keynote address at the Melbourne, Florida, campus during the university's Space Technology Day. Among the key topics Bridenstine discussed was NASA's Artemis missions to the Moon, including the lunar Gateway, which will serve as an orbiting outpost for astronauts. Photo credit: NASA/Kim Shiflett

NASA Administrator Jim Bridenstine, center, and Kennedy Space Center Director Bob Cabana, right, visit Florida Institute of Technology on May 23, 2019. Bridenstine delivered the keynote address at the Melbourne, Florida, campus during the university's Space Technology Day. Trent Smith, NASA Veggie project manager, far right, talks to Bridenstine about Space Technology and plant growth systems in use on the International Space Station. Photo credit: NASA/Kim Shiflett

Inside View

Kennedy engineer cherishes memorable moment during historic launch

BY JIM CAWLEY

The decision as to whether Torey Long would share the experience of viewing the historic March 2, 2019, **SpaceX Demo-1** launch from Florida's Kennedy Space Center with her family first required an important vote. A targeted 2:49 a.m. liftoff from Launch Complex 39A meant waking her children — ages 7, 5 and 2 — in the middle of the night.

"I put it to my kids the night before, 'If any of you want to go, I'll take you,'" Long said. "And JW, my oldest, was my only taker."

As the Launch Vehicle Materials and Processes system manager supporting the **Commercial Crew Program (CCP)** at Kennedy, Long spent plenty of time working on Demo-1, the first commercially-built and operated American crew spacecraft and rocket to launch from American soil on a mission to the International Space Station. Watching the uncrewed Dragon spacecraft liftoff aboard a SpaceX Falcon 9 rocket from Kennedy property with her son offered an entirely different perspective.

"Being able to share that with him and experience it in a different way … it was just such a moment," Long said. "He got to see what Mom does and why it's important — the 'why' behind it all.

"Such a big part of my life goes into the launch vehicle; that's the part for me that I'm watching and cheering."

Long's current responsibilities include working on NASA certification of all the materials and processes for the launch vehicles used by the agency's commercial partners, Boeing and SpaceX. She reviews designs and certification products, verifying they meet the intent of the NASA standard for materials and processes.

"Having dedicated people willing to support a program — willing to sacrifice to support the program — is big, and Torey is a great example of that," said **Scott Colloredo**, deputy director of Engineering at Kennedy. "You immediately know that she is very professional, gets her job done, and she has a really technically complex job to do."

Long graduated from Auburn University with a degree in materials engineering, then earned her master's in materials and science engineering from the University of Florida. These fields of study were sparked by a high school summer program that included a scanning electron microscope.

Left: Torey Long is the Launch Vehicle Materials and Processes system manager supporting the Commercial Crew Program at NASA's Kennedy Space Center. Photo credit: NASA/Kim Shiflett

Right: A two-stage SpaceX Falcon 9 rocket lifts off from Launch Complex 39A at NASA's Kennedy Space Center for Demo-1, the first uncrewed mission of the agency's Commercial Crew Program. Liftoff was at 2:49 a.m., March 2, 2019. The SpaceX Crew Dragon's trip to the International Space Station was designed to validate end-to-end systems and capabilities, leading to certification to fly crew. NASA has worked with SpaceX and Boeing in developing the Commercial Crew Program spacecraft to facilitate new human spaceflight systems launching from U.S. soil with the goal of safe, reliable and cost-effective access to low-Earth orbit destinations, such as the space station. Photo credit: NASA/Tony Gray

"And I was like, 'whatever I need to do in life to end up working one of those, I want to do,'" she said.

Long started at Kennedy as a co-op student in 2002 and became full-time at the spaceport in 2007. She worked in the Failure Analysis Laboratory, on different failures and investigations, in the Space Shuttle Program. After shuttle ended, she worked payload design, including **NASA's Vegetable Production System (Veggie)** and the **Advanced Plant Habitat (APH)**, where she was materials and processes discipline lead. Her team fabricated the Composite Growth Chamber in the prototype shop.

Long's first experience in CCP was as a Dragon subsystem manager, before moving into the system manager role. For her, coming out of a lab and moving into more design and certification work was a "natural progression of a skillset." She continues to do important work with Boeing and SpaceX, both of which are targeting crewed launches from Kennedy this year.

"It's fun working with innovative companies," Long said. "We encounter new challenges that we get to work on every day."

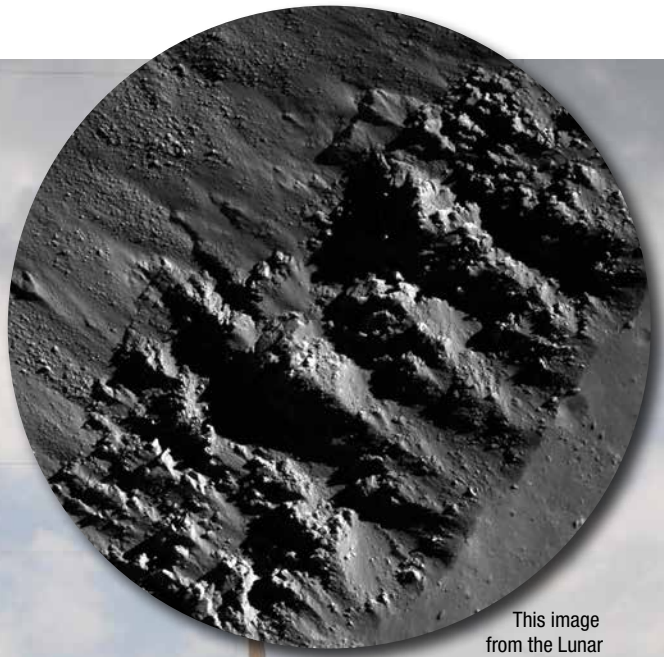
Each challenge that Long and her commercial crew coworkers overcome brings the program one step closer to a major milestone.

"It's inspiring to get to where we're going to launch people again from here — that's the biggest aspect of it is, 'wow, we are so close to the finish line; we are *so* close,' Long said. "And being involved in that from years ago to now is the most exciting part."

NASA Administrator Jim Bridenstine, at the podium, speaks to members of the news media at the NASA News Center at Kennedy Space Center in Florida on May 23, 2019. At left is Kennedy Space Center Director Bob Cabana. News media were at the center for an Apollo 11 Media Day. They toured several facilities, including the Vehicle Assembly and Launch Complex 39B for a look back at the Apollo missions and a look ahead to NASA's new Moon 2024 initiative, the Artemis 1 mission and the Gateway lunar outpost. Photo credit: NASA/Kim Shiflett

Senior leadership from NASA Headquarters and agency centers held a retreat at the Beach House at Kennedy Space Center in Florida on May 30, 2019. NASA Administrator Jim Bridenstine is in the front row, sixth from the left. Kennedy Director Bob Cabana is in the back row, far right. Photo credit: NASA/Frank Michaux

NASA's Lunar Reconnaissance Orbiter (LRO) and Lunar Crater Observation and Sensing Satellite (LCROSS) launched on an Atlas V rocket from Space Launch Complex 41 on June 18, 2009. Their destination was the Moon. Their goal was to map the Moon's surface like never before, with an expanded science mission after the first year. LRO was the first Near Earth NASA mission to utilize the Ka-band via the 18 meter antennas in White Sands, New Mexico. Ka-band communications allowed scientists to receive high-resolution pictures and 3D maps of the lunar surface in near real time. Photo credit: NASA



This image from the Lunar Reconnaissance Orbiter shows the upper southeastern portion of the rim of Piazzi H crater, which has a diameter of 5 miles. The width of this image if less than .5 miles and North is up. Photo credit: NASA/GSFC/ Arizona State University

For updates visit **https://www.nasa.gov/mission_pages/LRO/main/index.html**

National Aeronautics and Space Administration

John F. Kennedy Space Center
Kennedy Space Center, FL 32899

www.nasa.gov

NP-2019-06-1781-KSC