



KENNEDY SPACE CENTER'S  
SPACEPORT  
m a g a z i n e

**NASA's TESS  
Spacecraft  
Embarks  
on Hunt for  
Exoplanets**



# KENNEDY SPACE CENTER'S SPACEPORT MAGAZINE CONTENTS

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**Cover:** A SpaceX Falcon 9 rocket lifts off from Space Launch Complex 40 at Cape Canaveral Air Force Station in Florida on April 18, 2018, carrying NASA's Transiting Exoplanet Survey Satellite (TESS). Liftoff was at 6:51 p.m. EDT. TESS will search for planets outside of our solar system. The mission will find exoplanets that periodically block part of the light from their host stars, events called transits. The satellite will survey the nearest and brightest stars for two years to search for transiting exoplanets. Photo credit: NASA/Tony Gray

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National Aeronautics and Space Administration



**KENNEDY**  
SPACE CENTER



**ARIEL PAVLICK**

**Engineering Program Analyst  
Exploration Ground Systems**

I have worked at Kennedy Space Center for 10 years, and just over a year in my current role.

With more than a decade under my belt as an electrical engineer, I needed to learn how to speak the language of NASA. I left Kennedy for a one-year detail in the Office of the Chief Engineer at NASA Headquarters in Washington, D.C., which opened my eyes to how to effectively describe a project in terms of cost, schedule and risks within the context of NASA's overall scope and direction.

Exploration Ground Systems (EGS) has let me put that vision into practice.

In EGS, we are building the next generation of ground systems for the newest and biggest launch vehicle. We touch almost everything on center – the launch pad, the VAB and more – and will perform the work for processing flight hardware. I'm part of the team responsible for keeping track of how all the work we have to accomplish fits together.

The biggest challenge for me is keeping an eye on the relative importance of the different issues I encounter, and how those issues are communicated through the schedule, budget and risks.

My favorite Kennedy Space Center memory is either sitting in the cockpit of Atlantis as she was standing on the launch pad in anticipation of her final launch, or seeing noctilucent clouds over the VAB.

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# PLANET HUNTER

TESS spacecraft begins quest to find habitable extrasolar planets

BY ANNA HEINEY

NASA will have a new tool in the search for habitable planets.



Technicians prepare NASA's Transiting Exoplanet Survey Satellite (TESS) for encapsulation April 9, 2018, in the SpaceX payload fairing inside the Payload Hazardous Servicing Facility at the agency's Kennedy Space Center. Photo credit: NASA/Kim Shiflett

The agency's Transiting Exoplanet Survey Satellite was delivered to space aboard a SpaceX Falcon 9 rocket that lifted off April 18, 2018, from Space Launch Complex 40 at Cape Canaveral Air Force Station in Florida. Launch occurred right on time at 6:51 p.m. EDT following an uneventful countdown highlighted by excellent weather and healthy hardware.

"Liftoff of the SpaceX Falcon 9 rocket carrying TESS, a planet-hunting spacecraft that will search for new worlds beyond our solar system," NASA Launch Commentator Josh Finch said as the rocket thundered away from the launch complex.

TESS will be the first space-based, all-sky surveyor to search for exoplanets – planets outside of our own solar system. However, the spacecraft isn't looking for just any planets. It's specifically searching for those that are Earth-like, and close enough to our own celestial neighborhood that scientists can study them further.

"We are thrilled TESS is on its way to help us discover worlds we have yet to imagine, worlds that could possibly be habitable, or harbor life," said Thomas Zurbuchen, associate administrator of NASA's Science Mission Directorate in Washington.

How will it find these planets? Like the [Kepler mission](#) before it, TESS will use the transit method – that is, it will stare intently at

the stars in a given section of the sky, watching for the telltale flicker of a passing (transiting) planet. (Learn more about TESS and the transit method on the [TESS Overview](#).) Kepler, which launched in 2009, focused on one portion of the sky and sought to find Earth-like planets. TESS, on the other hand, will look for stars 30 to 100 times brighter than those observed by Kepler. It also will scan a far larger area.

But first, TESS had to get off the ground. After liftoff, the Falcon 9 rocket performed well, sending the spacecraft on its way to orbit. At 7:53 p.m., the twin solar arrays that will power the spacecraft successfully deployed.

"Wow, are we excited. We just had a perfect countdown and perfect launch of the TESS mission," said Tim Dunn of NASA's Launch Services Program. "The Falcon 9 continues to demonstrate what a reliable vehicle it has become," Dunn said.

Over the course of several weeks, TESS will use six thruster burns to travel in a series of progressively elongated orbits to reach the Moon, which will provide a gravitational assist so that TESS can transfer into its 13.7-day final science orbit around Earth. After approximately 60 days of check-out and instrument testing, the spacecraft will begin its work.



A SpaceX Falcon 9 rocket lifts off from Space Launch Complex 40 at Cape Canaveral Air Force Station in Florida on April 18, 2018, carrying NASA's Transiting Exoplanet Survey Satellite (TESS). Liftoff was at 6:51 p.m. EDT. TESS will search for planets outside of our solar system. The mission will find exoplanets that periodically block part of the light from their host stars, events called transits. The satellite will survey the nearest and brightest stars for two years to search for transiting exoplanets. Photo credit: NASA/Tony Gray



## Space Launch System flight hardware touches down at Kennedy

BY LINDA HERRIDGE

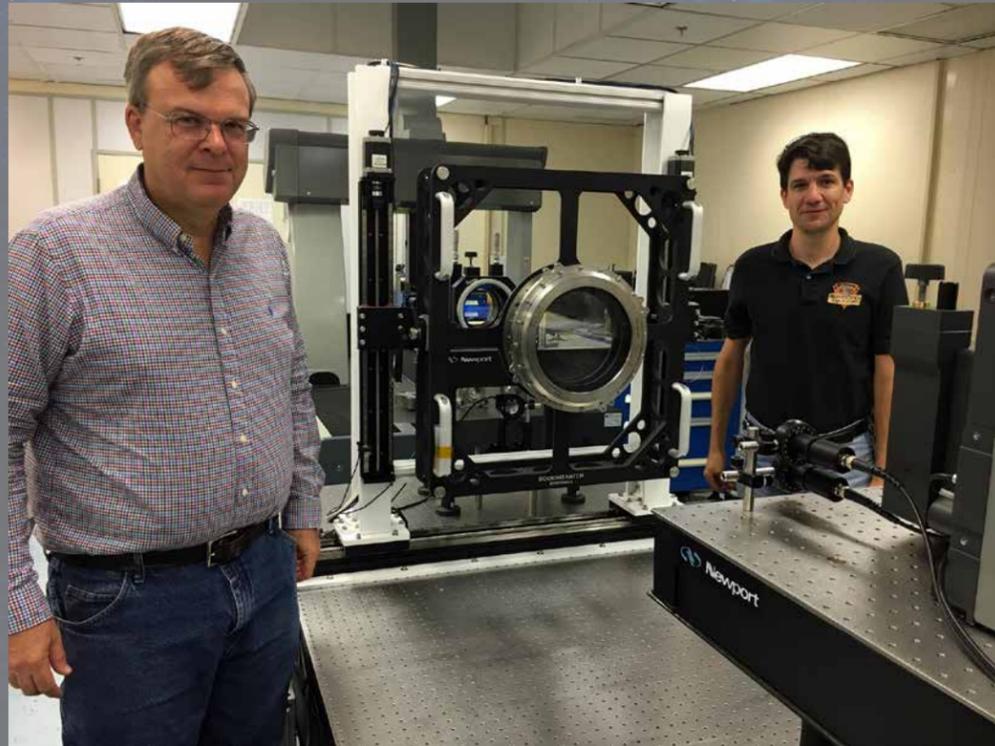
The second piece of flight-hardware for NASA's new exploration-class rocket, the **Space Launch System**, arrived at Kennedy Space Center on April 3. The Orion Stage Adapter (OSA) traveled to Kennedy aboard NASA's **Super Guppy** aircraft from the agency's Marshall Space Flight Center in Huntsville, Alabama, where it was built.

The stage adapter will connect the **Orion** spacecraft to the upper part of the rocket, known as the interim cryogenic propulsion stage, or ICPS. The ICPS is a liquid oxygen/liquid hydrogen-based upper space stage that will give the spacecraft the push needed to go to deep space.

On its first launch, the OSA will double as a secondary payload carrier, delivering 13 mini ships on as many deep space missions. These small but mighty scientific investigations include 10 satellites from U.S. industry, government and commercial partners, as well as the three CubeSats being built by international partners.

Both the OSA and ICPS are being stored for processing in Kennedy's Space Station Processing Facility in preparation for **Exploration Mission 1**, the first integrated launch of the SLS rocket and Orion spacecraft.

The Orion Stage Adapter arrived at NASA's Kennedy Space Center on April 3 and was transported to the Space Station Processing Facility. Photo credit: NASA/Kim Shiflett

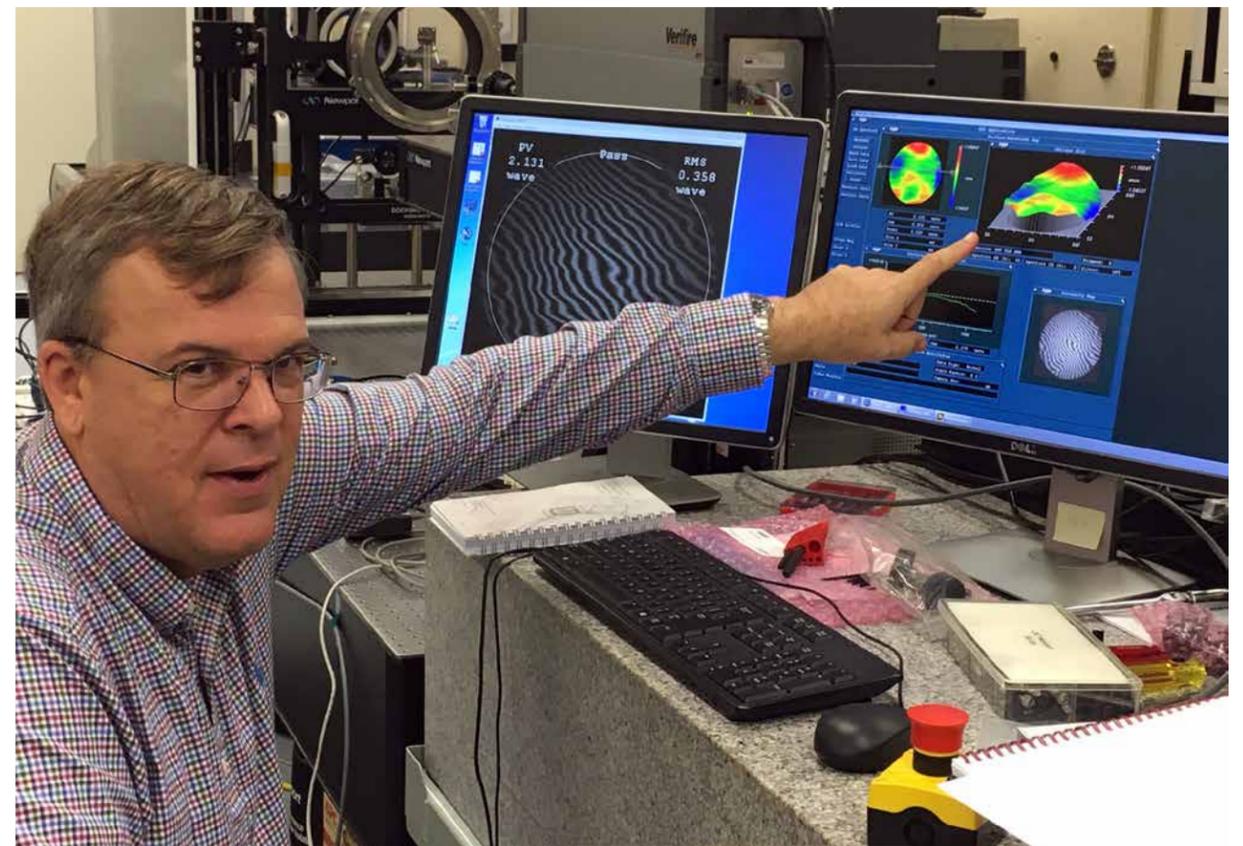


Inside a laboratory in the Neil Armstrong Operations and Checkout Building at NASA's Kennedy Space Center, Mark Nurge, Ph.D., at left, a physicist in the Applied Physics Lab with the center's Exploration Research and Technology Programs, and Bence Bartha, Ph.D., a specialist in non-destructive testing with URS Federal Services, are performing the first optical quality testing on a full window stack that is ready for installation in the docking hatch of NASA's Orion spacecraft. The data from the tests will help improve the requirements for manufacturing tolerances on Orion's windows and verify how the window should perform in space. Orion is being prepared for its first integrated uncrewed flight atop NASA's Space Launch System rocket on Exploration Mission-1. Photo credit: NASA/Amanda Griffin

# A WINDOW TO SPACE

BY LEEJAY LOCKHART AND AMANDA GRIFFIN

A few multi-layer windows on a spacecraft provide astronauts the view they may need for navigating space and carrying out their exploration mission with visual data.



Mark Nurge looks at data during the first optical quality test on a full window stack that is ready for installation in the docking hatch of NASA's Orion spacecraft. Photo credit: NASA/Amanda Griffin

NASA is working to improve the durability of those windows, and reduce cost and weight, while maintaining the clarity astronauts need to carry out their tasks and view the Earth and other destinations as they travel farther into the solar system.

The space shuttle used only glass panes for its primary windows. While these provided good optical quality, they added costly mass to the spacecraft. Modern spacecraft windows incorporate acrylic and other plastics that are lighter, stronger and less brittle, but often provide lower quality optical properties.

A few years ago, NASA began an effort to ensure the optical quality of the panes used on agency or commercial spacecraft. Each window pane must ensure the view is clear for the astronauts and to help their cameras capture the best possible photographs.

Recently, a team from **Kennedy Space Center's** Exploration Research and Technology Programs performed the first optical quality testing on a window that is ready for installation in the docking hatch of **NASA's Orion** spacecraft. On Orion, three panes comprise the hatch window. This hybrid combination of glass and plastics is a first for NASA and will safeguard the spacecraft's inhabitants as one glass pane shields them from the heat of re-entry, another acrylic pane provides protection from the vacuum that surrounds the craft when it is outside of Earth's atmosphere, and the third pane serves as a redundancy for the glass pane.

When you use multiple panes of material for a window, the image you see out of it could be distorted. The tests performed determine the amount of image distortion – the variations in the image seen through an optical material. These are wavefront variations. Think of it as looking at something in water when the surface is moving.

However, according to Kennedy's Mark Nurge, this Orion window shouldn't be a problem. "The window assembly was approximately 10 times better than the stated wavefront requirements," he said.

The data from the tests help improve the requirements for optical quality on Orion's windows and verify how the window should perform in space. The Kennedy team is responsible for testing all the viewing and hatch windows for Orion, and also is working with **Commercial Crew Program** providers to test windows for their spacecraft headed to the **International Space Station**.

The primary test measures variations in window pane flatness with an accuracy down to the level of tens of nanometers. The device used in the test can show minute differences between new windows and ones that have been subjected to the simulated pressures of space. The ultimate goal is to determine if there are any distortions outside of the prescribed threshold, so the astronauts onboard the spacecraft can take the most precise images possible.

These window tests are another step towards completion of Orion as the spacecraft is prepared to take humans farther into space than ever before.

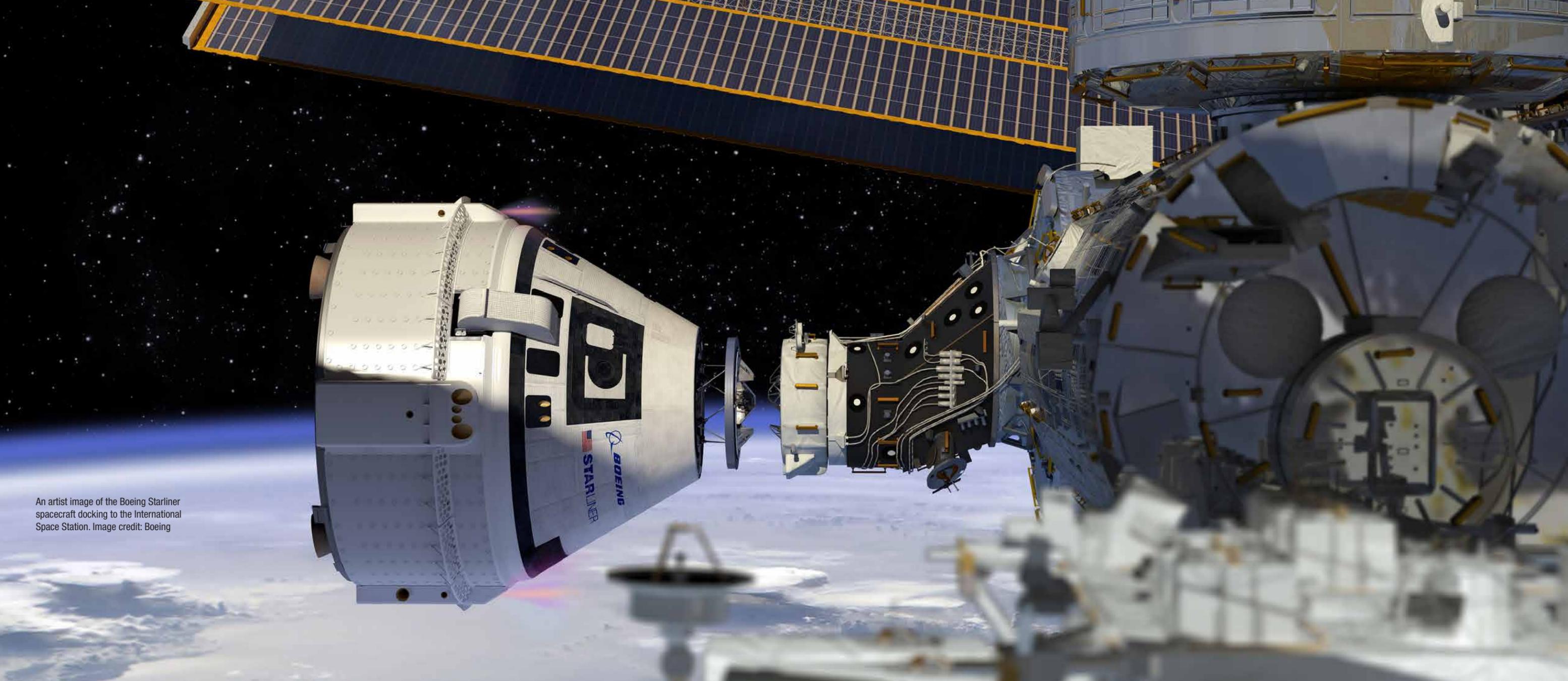


**N**ASA's Interior Exploration using Seismic Investigations, Geodesy and Heat Transport, or InSight, at right, is in a clean room inside the Astrotech processing facility at Vandenberg Air Force Base in California. The spacecraft's protective heat shield is in view at left. InSight is scheduled for liftoff on a United Launch Alliance Atlas V rocket May 5, 2018.

InSight will be the first mission to look deep beneath the Martian surface. It will study the planet's interior by measuring its heat output and listen for marsquakes. InSight will use the seismic waves generated by marsquakes to develop a map of the planet's deep interior. The resulting insight into Mars' formation will provide a better understanding of how other rocky planets, including Earth, were created.

NASA's Jet Propulsion Laboratory in Pasadena, California, manages the InSight mission for the agency's Science Mission Directorate. InSight is part of NASA's Discovery Program, managed by its Marshall Space Flight Center in Huntsville, Alabama. The spacecraft, including cruise stage and lander, was built and tested by Lockheed Martin Space in Denver. Several European partners, including France's space agency, the Centre National d'Étude Spatiales, and the German Aerospace Center, are supporting the mission. United Launch Alliance of Centennial, Colorado, is providing the Atlas V launch service. NASA's Launch Services Program, based at its Kennedy Space Center in Florida, is responsible for launch management.

Photo credit: USAF 30th Space Wing/Chris Wiant and Dan Herrera



An artist image of the Boeing Starliner spacecraft docking to the International Space Station. Image credit: Boeing

## NASA, Boeing may evolve flight test strategy

NASA has updated its Commercial Crew Transportation Capability (CCtCap) contract with Boeing, which provides flexibility in its commercial flight tests. Boeing, one of the agency's two **commercial crew partners**, approached NASA last year and proposed adding a third crew member on its Crew Flight Test (CFT) to the **International Space Station**.

The change includes the ability to extend Boeing's CFT from roughly two weeks to up to six months as well as the training and mission support for a third crew member. Cargo capabilities for the uncrewed and crewed flight tests were also identified.

Exact details of how to best take advantage of the contract modification are under evaluation, but the changes could allow for additional microgravity research, maintenance, and other activities

while Starliner is docked to station. Adding a third crew member on Boeing's flight test could offer NASA an additional opportunity to ensure continued U.S. access to the orbital laboratory.

"This contract modification provides NASA with additional schedule margin if needed," said William Gerstenmaier, associate administrator, Human Exploration and Operations Mission Directorate at NASA Headquarters in Washington. "We appreciate Boeing's willingness to evolve its flight to ensure we have continued access to space for our astronauts. Commercial space transportation to low-Earth orbit from U.S. soil is critical for the agency and the nation."

The current commercial crew flight schedules provide about six months of margin to begin regular, post-certification crew rotation

missions to the International Space Station before NASA's contracted flights on Soyuz flights end in fall 2019.

"Turning a test flight into more of an operational mission needs careful review by the technical community," said Gerstenmaier. "For example, the spacecraft capability to support the additional time still needs to be reviewed. Modifying the contract now allows NASA and Boeing an opportunity to tailor the duration to balance the mission needs with vehicle and crew capabilities."

This would not be the first time NASA has expanded the **scope of test flights**. NASA had SpaceX carry cargo on its commercial cargo demonstration flight to the International Space Station under the Commercial Orbital Transportation Services (COTS) initiative in 2012, which was not part of the original agreement. As part of its normal operations planning, NASA has assessed multiple scenarios to ensure continued U.S. access to the space station. The agency

is working closely with its commercial partners and is preparing for potential schedule adjustments normally experienced during spacecraft development.

"Our partners have made significant progress on the development of their spacecraft, launch vehicle, and ground systems," said Kathy Lueders, NASA's Commercial Crew Program manager at Kennedy Space Center in Florida. "Their rigorous testing and analysis are verifying each system performs and reacts as planned as they prepare to safely carry our astronauts to and from the station."

Boeing and SpaceX **plan to fly test missions** without crew to the space station this year prior to test flights with a crew onboard. After each company's test flights, NASA will evaluate the in-flight performance in order to certify the systems and begin regular post-certification crew rotation missions.

## Space explorers inducted into U.S. Astronaut Hall of Fame

BY LINDA HERRIDGE

The Space Shuttle Atlantis attraction served as the backdrop for the U.S. Astronaut Hall of Fame (AHOF) induction ceremony April 21 at NASA's Kennedy Space Center Visitor Complex in Florida. Beneath Atlantis, two veteran space explorers, Scott D. Altman and Thomas D. Jones, were inducted as the class for 2018. This year's induction brings the total number of AHOF members to 97.

Master of Ceremonies John Zarrella praised the inductees for their contributions to NASA's space program. Together, Altman and Jones have a combined 93 days in space.

"Today we're here to honor two space explorers who have flown a combination of eight space shuttle missions, one as a pilot and commander, one as a scientist and spacewalker," Zarrella said. "One is named in movie credits, one has an asteroid named for him."

They each received an official medal and were inducted by former NASA astronaut and Hall of Famer Curt Brown, board chairman, Astronaut Scholarship Foundation (ASF).

### THOMAS D. JONES

"I dreamed of working here," Jones said. "It's gratifying to join this group. This event continues to further the Mercury astronauts' vision. Thank you for this great honor."

The Baltimore, Maryland, native attended the U.S. Air Force Academy in Colorado Springs and earned a Bachelor of Science in basic sciences in 1977. He earned a doctorate in planetary science from the University of Arizona in Tucson in 1988, graduating Phi Beta Kappa. In 1990, Jones joined Science Applications International Corporation in Washington as a senior scientist. He performed advanced program planning for NASA's Solar System Exploration Division, investigating future robotic missions to Mars, asteroids and the outer solar system.

After a year of training following his selection by NASA in January 1990, Jones became an astronaut in July 1991. His space shuttle missions include STS-59 aboard Endeavour in April 1994, and payload commander on STS-68 in October 1994, again on Endeavour. His next mission was STS-80 aboard Columbia in late 1996. During that mission, he helped set a shuttle endurance record of nearly 18 days in orbit. Jones used Columbia's robotic arm to release the Wake Shield satellite and later grapple and retrieve it from orbit.

His final space flight was aboard Atlantis on STS-98 in February



Two space pioneers were inducted into the U.S. Astronaut Hall of Fame during a ceremony April 21, 2018, at NASA's Kennedy Space Center Visitor Complex in Florida. From left, are Curt Brown, board chairman, Astronaut Scholarship Foundation and Hall of Fame member; Scott Altman, retired astronaut and 2018 inductee; John Grunsfeld, Hall of Fame member who spoke on behalf of Altman; and Tom Jones, retired astronaut and 2018 inductee. Not pictured: Storey Musgrave, Hall of Fame member who spoke on behalf of Jones. Photo credit: Kennedy Space Center Visitor Complex/Chris Gotshall

2001. Jones and his crew delivered the U.S. Destiny Laboratory Module to the International Space Station. During a series of three spacewalks totaling more than 19 hours, he helped install the lab and gave the first Expedition Crew the largest space outpost in history. Delivery of the lab also marked the start of onboard scientific research on the space station.

Jones retired from NASA in 2001 with a total mission time of 53 days and 48 minutes and three spacewalks. He has written several books, including "Sky Walking: An Astronaut's Memoir," and National Geographic's "Planetology: Unlocking the Secrets of the Solar System."

He currently writes, speaks and consults on space exploration, space operations, space resources and planetary defense. The Main Belt asteroid 1082 TomJones is named in his honor.

"The space program gave me immense pride in my country," Jones said. "Becoming an astronaut was certainly 'the best job I've ever had.'"

### SCOTT D. ALTMAN

Altman, nicknamed "Scooter," was always fascinated with the idea of flying. When he was young, he told his parents he wanted to be a pilot.

"I'm happy to finally be here. It's a wonderful day. I thank God for all the blessings in my life," Altman said.

Altman earned a degree in aeronautical and astronautical engineering at the University of Illinois. While attending college,

the U.S. Navy sent him a brochure and he was quickly sold on becoming a Navy aviator. While based at the Navy's Top Gun School at Air Station Miramar in San Diego, California, Altman flew the F-14 Tomcat. When the 1986 movie, "Top Gun" was filmed, Altman — call sign "Scooter" — stood in for Tom Cruise's character, "Maverick," and flew an F-14 jet in aerobatic flight sequences.

Altman graduated from the Navy Test Pilot School in June 1990. Five years later, he was selected by NASA as an astronaut and reported to Johnson Space Center in Houston in March 1995.

He served as pilot on his first mission, STS-90, aboard Columbia in April and May 1998. The 16-day mission of the European Space Agency's Spacelab laboratory module focused on the effects of microgravity on the human anatomy. Two years later, he served as pilot for STS-106 aboard Atlantis in September 2000.

In March 2002, the shuttle Columbia lifted off on STS-109 with Altman as commander for the fourth Hubble Space Telescope servicing mission. Over 11 days, spacewalking astronauts upgraded the telescope with improved solar arrays, a new camera and a power control unit for the orbiting observatory. On Altman's fourth and final flight, STS-125 in May 2009, he again served as commander, this time aboard Atlantis. It was the final Hubble Space Telescope servicing mission, during which the crew performed five spacewalks to replace cameras, a guidance sensor, gyroscopes and battery units.

Following STS-125, Altman served as the chief of the Exploration Branch of the Astronaut Office. He participated in the development of NASA's next human-rated spacecraft, Orion, designed to take crews to deep space or to the Lunar Orbital Platform-Gateway.

Altman retired from NASA in September 2010. He joined Arctic Slope Regional Corporation's Federal Research and Technology Solutions in Greenbelt, Maryland, as senior vice president of Civil Programs.

"Finding that challenge and continuing to grow is a lifelong endeavor," Altman said. "We don't just look back, we also look forward."

"It's such an honor to join this group of my much more accomplished and famous colleagues. I stand in awe of them," Jones said. "Exploration is a story without an end. Many of the young people here will write their own chapters in that story. I can't wait to see what discoveries they reveal."

When asked if he had any advice for students, Altman said, "Keep trying, do your best, don't give up and always follow your dreams."

The 2018 inductees were selected by a committee of Hall of Fame astronauts, former NASA officials, flight directors, historians and journalists. The process is administered by the ASF, which was founded by the original seven Mercury astronauts in 1984. To be eligible, an astronaut must have made his or her first flight at least 17 years before the induction and retired from NASA for at least five years. Each candidate must be a U.S. citizen and a NASA-trained commander, pilot or mission specialist who has orbited Earth at least once.

Brown said the ASF has awarded nearly \$5 million to more than 500 college students majoring in science, technology, engineering and mathematics, or STEM, studies.

## 2018 INDUCTEES



Astronaut Scott Altman, STS-90 pilot, works with the Portable In-flight Landing Operations Trainer (PILOT) laptop at his station on space shuttle Columbia's forward flight deck. Columbia launched April 17, 1998 and returned to Earth on May 3, 1998. Photo credit: NASA



Astronaut Tom Jones, STS-98 mission specialist, grabs a hand rail while working on the International Space Station during the second of three scheduled space walks involving himself and astronaut Robert L. Curbeam and assisted by their STS-98 crew mates aboard space shuttle Atlantis on Feb. 12, 2001. The scene was recorded with a digital still camera. Photo credit: NASA



Sustainability innovations took center stage during Kennedy Space Center's annual Earth Day celebration April 17 and 18. The two-day event was held at two spaceport locations – one day at the Kennedy Space Center Visitor Complex, the next at the center's Space Station Processing Facility – offering up plenty of opportunities for guests and employees alike to learn more about new, Earth-friendly technologies we can use to improve our own lives at work and at home. The event was highlighted by 50 exhibitors who were ready to share their expertise on a wide range of topics, including electric vehicles, sustainable lighting, renewable energy, Florida-friendly landscaping tips, Florida's biking trails and more. Inset: Students from Rockledge High School in Rockledge, Florida, make "plarn" – plastic yarn -- out of used plastic bags. Photo credits: NASA/Frank Michaux

# NEW APPROACH

## Tupperware takes to space to help improve astronaut diets

BY AMANDA GRIFFIN



Howard Levine, Ph.D., a research scientist at NASA's Kennedy Space Center in Florida, reviews the growth of several tomato plants in a laboratory in the Space Station Processing Facility. The tomato plants are growing in the Veggie Passive Orbital Nutrient Delivery System (PONDS). Veggie PONDS is a direct follow-on to the Veg-01 and Veg-03 hardware and plant growth validation tests. PONDS is planned for use during Veg-04 and Veg-05 on the International Space Station after the Veggie PONDS Validation flights on SpaceX-14 and OA-9. Photo credit: NASA/Cory Huston

For decades, airtight plastic containers have been synonymous with keeping baked goods and leftovers fresh. Now a manufacturer of iconic, household plasticware is helping provide fresh food in space.

As the agency plans for future missions to **deep space destinations**, the nutritional boost of fresh food and the psychological benefits of growing plants becomes more and more paramount. Since 2015, NASA astronauts have supplemented their space diet with fresh greens grown in the Vegetable Production System known as **Veggie** on the **International Space Station**.

One of the challenges with growing plants in space in Veggie has been keeping them properly watered. The Tupperware Brands Corporation has lent its design expertise to help develop a new approach to watering plants in space.

With the Veggie system, astronauts have to push water into each plant pillow with a syringe. In previous crops grown in the Veggie system using pillows, some plants fared better than others because

not all the plants received equal amounts of water and oxygen.

"The primary goal of this newly developed plant growing system, the Passive Orbital Nutrient Delivery System, or PONDS, is to achieve uniform plant growth," said Nicole Dufour, Veggie project manager at NASA's Kennedy Space Center in Florida.

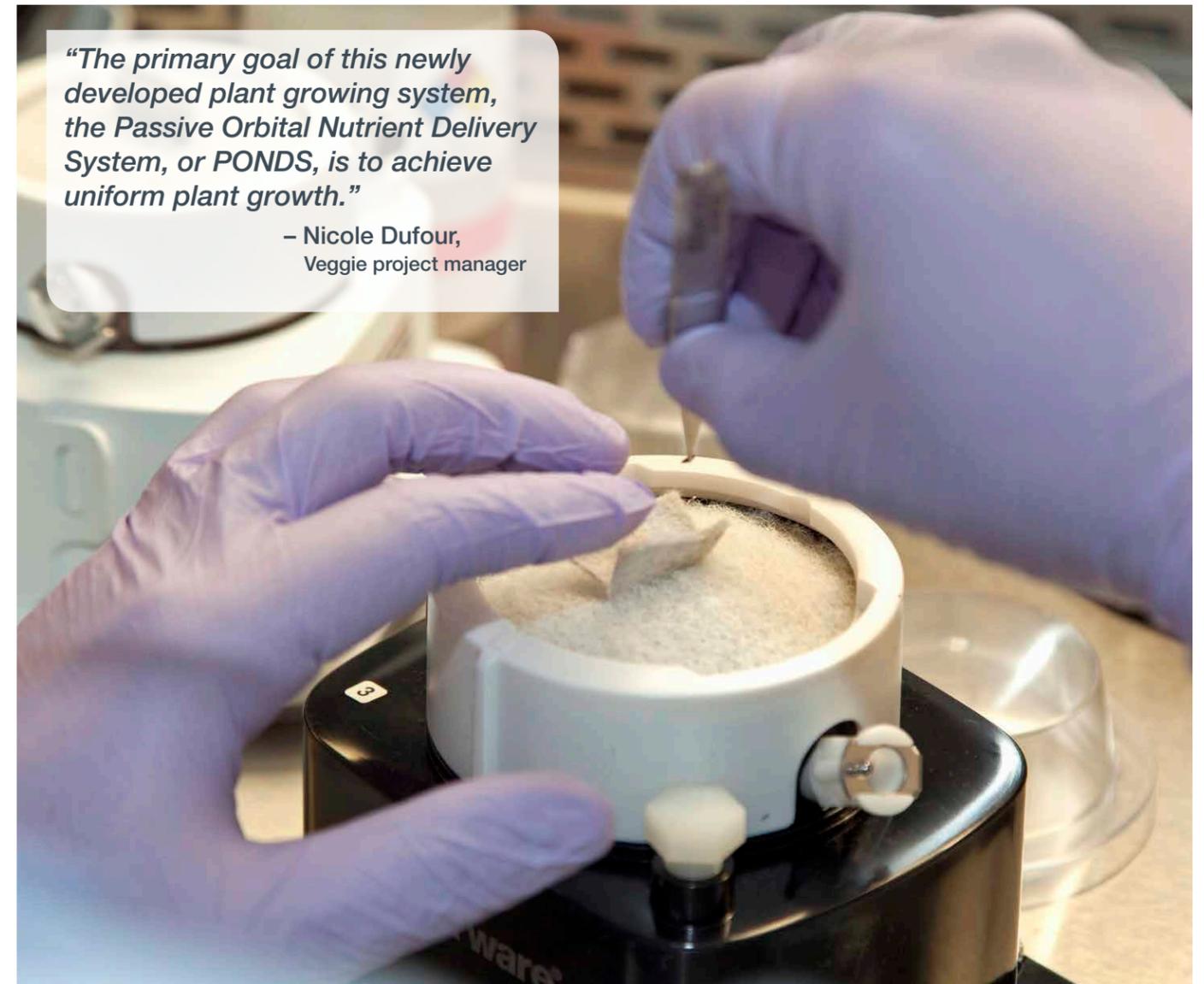
NASA research scientist Howard Levine initially designed and prototyped PONDS but in early 2017 handed it off to Techshot, a private spaceflight services firm, to further develop and certify the demonstration unit for use on the orbiting laboratory. In turn, Techshot reached out to Tupperware to help create the new system that would provide an alternative to the plant pillows.

"PONDS units have features that are designed to mitigate microgravity effects on water distribution, increase oxygen availability and provide sufficient room for root zone growth," Dufour explained.

The new PONDS system requires less crew maintenance and uses absorbent mats that leverage the basic principles of surface

*"The primary goal of this newly developed plant growing system, the Passive Orbital Nutrient Delivery System, or PONDS, is to achieve uniform plant growth."*

– Nicole Dufour,  
Veggie project manager



Seeds are being planted in Veggie Passive Orbital Nutrient Delivery System (PONDS) units inside a laboratory at the Space Station Processing Facility at NASA's Kennedy Space Center in Florida. Photo credit: NASA/Daniel Casper

tension and capillary action to wick water to seeds and roots through a reservoir system. This approach passively disperses water evenly through each plant cylinder contained within the PONDS' reservoirs, facilitating consistent seed germination and seedling development into mature plants.

"It's been great working closely with the talented teams of engineers, designers and scientists at NASA and Tupperware on the project," said Dave Reed, Techshot's PONDS project manager and the company's director of launch operations. "Tupperware brings a wealth of innovative design and knowledge of plastics to this project."

The upcoming **SpaceX CRS-14 commercial resupply mission** will include seven PONDS modules plus an adapter plate so the modules can be installed in the Veggie system. Included are four black opaque modules that will grow Outredgeous red romaine lettuce — the same lettuce that has been grown previously in the Veggie facility — for about a month. Two shrouded modules each include a clear window and removable cover that allow astronauts to

directly observe root growth of the same romaine lettuce plus assess water distribution in the hydroponic reservoir. One clear module will be used to perform testing and videography to characterize the microgravity hydrodynamics of the reservoir.

Six more PONDS modules are slated to launch on an Orbital ATK commercial resupply mission later this year and will be seeded with Mizuna mustard. Both the lettuce and the mustard have already been grown in plant pillows as a part of previous Veggie experiments, so the plant pillow and PONDS growth data will be compared against one another.

Kennedy is leading the way with more plant research opportunities than ever on the station, with two Veggie units, the **Advanced Plant Habitat** that just finished its first growth test, new **BRIC-LED** lighting that now provides illumination to drive photosynthesis, and testing genetic expression of organisms in space with the upcoming **Spectrum** experiment later this year.



Tessa Hanna, at right, an AmeriCorps Vista volunteer, helps students from schools in Columbus, Ohio, collect and record data on plants they are growing as part of The Fairchild Challenge. Photo credit: The Homeless Families Foundation/Jermaine Kennedy

# MORE OPTIONS

## Students help NASA researchers decide what plants to grow in space

BY AMANDA GRIFFIN

NASA scientists with advanced degrees aren't the only ones deciding what crops should be grown in space. Students, including a special group from Columbus, Ohio, also are taking a bite out of this tasty cause.

For the past couple years, NASA has been partnering with Fairchild Tropical Botanic Gardens in Miami, Florida, to encourage student interest in science, technology, engineering and math, or STEM. NASA partners with [The Fairchild Challenge](#), which reaches more than 125,000 students annually, to help determine which edible plants might be suitable for growth in microgravity aboard the International Space Station in the [Veggie](#) growth chamber.

The purpose of this ongoing series of experiments is to expand food options and increase plant diversity by testing multiple

edible plants that meet NASA's criteria for size and edibility. Using equipment that mimics the environmental conditions aboard the [International Space Station](#), students test factors that may influence plant growth, flavor and nutrition. NASA will use students' data to determine which plants to begin growing in space.

This year, the [Homeless Families Foundation](#) in Columbus added its students' talents to The Fairchild Challenge. The Homeless Families Foundation provides housing assistance and educational services for homeless families living in Columbus. They believe that stabilizing and empowering families, as well as providing quality education to at-risk and impoverished youth, is crucial in breaking the cycle of homelessness.

"You can't just put a roof over someone's head and expect them to come out of poverty," said Donna Bastian, director of donor relations for the foundation. "You need to educate them."

After school and during the summer, the foundation serves 80 elementary and middle school children with hands-on STEM and problem-solving activities. Twenty-five percent of those served have been homeless at some point, and all are living in poverty.

"We work to give these kids a better opportunity and expose them to every opportunity so they can see a way out and a future for themselves," Bastian said.

To accomplish this, the foundation tailors many of its activities to the individual interests of the children. According to Bastian, many were curious about gardening and cooking. Tessa Hanna, an AmeriCorps Vista volunteer working with the foundation, reached out to Mark Miller, outreach education manager at the nearby Franklin Park Conservatory, who connected Hanna and the students with The Fairchild Challenge in an effort to encourage these budding interests.

Once they began, the students were responsible for daily plant upkeep and data collection. Throughout the 28-day challenge, they also recorded weekly plant measurements that were sent in to The Fairchild Challenge.

The growing chamber that housed the plants was kept in the lobby area of the education center, which gave students who weren't participating in the challenge an opportunity to engage with the project. Through careful observation, students were able to identify that some plants are potentially better suited for the conditions present on the orbiting laboratory, where water is a limited resource.

"There were real life applications in our research for NASA," said fourth-grader Chance. "We learned how to take averages, grow plants, and convert Fahrenheit to Celsius. We also learned a lot about the effects of being in space and how nutritious food can keep people on Earth and in space healthy."

Students took ownership of the empirical aspects of the challenge, as well as the ones that allowed them to be more creative. The culmination of the plant growth phase of the project was the harvest day. After one final round of measurements, students weighed the edible biomass of each plant. They then used the species they had grown to make a delicious stir-fry they shared with all of the teachers at the center.

"All the students participating in the challenge have the 'right stuff,' and I really enjoyed seeing all the progress tweets," said NASA's Trent Smith, Veggie project manager at Kennedy Space Center. "This year it was especially inspiring for me to see our team of students associated with the Homeless Families Foundation growing plants and collecting data for our NASA scientists."



Students participating in The Fairchild Challenge in Columbus, Ohio, tweeted about their progress.



Two students from schools in Columbus, Ohio, check the height of a plant and record the data as part of The Fairchild Challenge. Photo credit: The Homeless Families Foundation/Jermaine Kennedy

# ALWAYS ON ALERT



NASA Kennedy Space Center Emergency Response Team members participate in an active shooter response exercise during the annual 88-hour Basic Tactical Operator Course at the center's Protective Services Training Facility. Photo credit: NASA/KSC Emergency Response Team

## EMERGENCY RESPONSE TEAM TRAINS TO PROTECT KENNEDY WORKFORCE AND ASSETS

BY LINDA HERRIDGE

Workforce protection is more than a number-one priority at NASA's Kennedy Space Center in Florida, especially in light of recent unfortunate events in Florida and around the country. The center's Emergency Response Team (ERT) trains year-round to be prepared for any high-risk critical incidents that may occur on center property, which extends outside of the badged entry gates and includes the nearby Kennedy Space Center Visitor Complex.

To keep current on their skills and knowledge, members of the ERT recently participated in their annual 88-hour Basic Tactical Operator Course.

"This course is mandatory for all newly assigned or hired SWAT officers, and is open to law enforcement and military personnel from outside agencies," said William Young, ERT commander and assistant chief of operations.

In addition to four newly hired Kennedy ERT officers, personnel from five outside agencies in Florida participated in the 88 hours of concentrated training exercises, including SWAT team members from the Cocoa, Sarasota and Sebastian police departments, Florida Fish and Wildlife Commission Special Operations Group, and Patrick Air Force Base ERT.

The training was coordinated and instructed by experienced SWAT/ERT officers from the Kennedy Team. It covered basic and advanced tactics, techniques and principles related to a SWAT Operator's mission, including firearms training, building entry, active shooter response, and response to hostage/barricade situations.

Participants trained at the center's NASA Protective Services Training Facility, where obstacle courses and building structures provided a challenging environment for them to train and enhance their skills necessary to be prepared for any threat.

Members of Kennedy's ERT also participate in the SWAT Roundup International, held each year in Orlando. The Roundup competition is open to law enforcement and military SWAT teams from around the world. During the 2017 Roundup, Kennedy placed fifth among the 55 teams participating, which included 46 teams from the U.S. and nine international teams.

"SWAT Roundup is very challenging and competitive for the team as well as for the individual officers, and finishing in the top 10 percent of teams is definitely rewarding," Young said.

Preparing for the Roundup includes physical training for strength, speed and stamina, proficiency with multiple weapons systems, rope/rappel training, and obstacle course training.

The competition includes five events that simulate real-life critical incidents that SWAT teams may encounter. These events include hostage rescue/barricade situations and officer/citizen down rescue operations. They require high levels of physical fitness and proficiency with all firearms and weapons systems; positive target



NASA Kennedy Space Center Emergency Response Team members exit a tactical vehicle during an active shooter response exercise at the center's Protective Services Training Facility. A helicopter hovers overhead. Photo credit: NASA/KSC Emergency Response Team



NASA Kennedy Space Center Emergency Response Team members and others from local law enforcement agencies participate in a training exercise at the center's Protective Services Training Facility. Photo credit: NASA/KSC Emergency Response Team

identification and use-of-force decision-making; and a thorough understanding of SWAT tactics and principles.

"The biggest payoff for us is the relationships we build and reinforce each year with the other teams," Young said. "The training sessions and time we spend with the other teams, especially those within our region, help us to evolve and improve, and to facilitate the integration of multiple teams and agencies when responding to potential large-scale critical incidents."

With the increasing threats currently faced by law enforcement, Young said there's nothing more important than continual evaluation and improvement of ERT capabilities and collaboration with partner agencies to protect the center and its workforce.

"At Kennedy, we don't train just for competition, we train for real-life situations," Young said.

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## Kennedy Space Center Director Bob Cabana updates National Space Club Florida Chapter

BY LINDA HERRIDGE

NASA's Kennedy Space Center is the 'Bridge to the Future.' Bob Cabana, Kennedy's center director, echoed these words from Vice President Mike Pence's most recent visit to the center during a presentation to members and guests of the National Space Club-Florida Committee on March 20, 2018.

"You just can't beat what we have accomplished since the retirement of the space shuttle," Cabana said. "I'm so pleased that we have a clear vision forward, and what we have to accomplish in the future."

Cabana was happy to report that each of the programs at Kennedy -- Exploration Ground Systems, Launch Services Program and Commercial Crew Program -- are in a very stable position as the center moves forward.

Exploration Ground Systems (EGS) has come a long way in the past two years. Mid-year, EGS will have completed all of the infrastructure necessary to process and launch Orion and the Space Launch System. The team recently tested Orion recovery processes and procedures aboard the USS Anchorage in the Pacific Ocean. The final two large swing arm umbilicals have been installed on the tower of the mobile launcher. Preparations for the arrival of the SLS solid rocket motors were completed in the Rotation, Processing and Surge Facility.

"Inside the Vehicle Assembly Building, High Bay 3 is ready to go," Cabana said. "We've got all of the work platforms installed. We're ready to get the mobile launcher in there and begin verification and validation testing."

Crawler-transporter 2 was totally refurbished in preparation for its role in missions to come. The crawler will carry the SLS rocket with Orion atop the mobile launcher to Launch Pad 39B for Exploration Mission-1, and will one day carry the rocket that will take us to Mars. At the launch pad, work is underway to complete the flame deflector in the flame trench. The upgraded environmental control system is undergoing verification and validation.

Read the full story at <https://go.nasa.gov/2qHDUGX>.

Kennedy Space Center Director Bob Cabana speaks to National Space Club-Florida Chapter members and guests at the Radisson Resort at the Port in Cape Canaveral, Florida. Photo credit: NASA/Ben Smegelsky



Acting NASA Administrator Robert Lightfoot, fourth from right, attended the National Space Symposium in Colorado Springs, Colorado, with members of NASA's Partnership Team on April 17, 2018. They highlighted the advantage of working with NASA to advance the agency's mission and program objectives, including international cooperative space activities. Photo credit: NASA/Tom Engler

# BREAKING BARRIERS

Space pioneer JoAnn Morgan shares story during Women's History Month event

BY LINDA HERRIDGE



JoAnn Morgan, former associate deputy director of NASA's Kennedy Space Center, was the keynote speaker during a Women's History Month event March 27, at the center. With the theme "Nevertheless She Persisted," Morgan described her experience as the first female engineer working in the space program in the 1960s. Photo credit: NASA/Leif Heimbald

## ***"Nevertheless, She Persisted,"***

was the theme of this year's Women's History Month event, hosted by the Networking Opportunities for Women organization at NASA's Kennedy Space Center in Florida. Keynote speaker was U.S. space program trailblazer JoAnn Morgan, former associate deputy director of the center.

Morgan began her space career in summer 1958, at the young age of 17, as a student intern with the U.S. Army Ballistic Missile Agency at Cape Canaveral Air Force Station. She was the first female engineer at Kennedy and the only woman, among a sea of men, who was present in the firing room during NASA's Saturn V/Apollo 11 launch to the Moon.

In the early days of her 40-plus-year career with NASA, she had the opportunity to work on a variety of projects. She developed algorithms for a Mars trajectory, worked in the Vehicle Assembly Building and helped develop the space shuttle launch processing system central data subsystem. She also worked on site activation for the Launch Control Center firing room consoles.

"Kennedy Space Center had an environment that allowed women to thrive," Morgan said. "There were no dull days. I learned something from every experience."

Morgan said she had supervisors who were very supportive of her efforts. One of her personal credos is the word "ARE," which stands for acceptance, respect and equality.

She was pictured in national magazines during the 1960s as the only female on the Apollo launch team among hundreds of men. Morgan also was on the launch team for the Apollo-Soyuz and Skylab launches.

She served in several positions at Kennedy, including director of Payload Projects Management, and director of Safety and Mission Assurance, one of the last two people who verified the space shuttle was ready to launch. She was the first woman to serve in an executive position, associate deputy director of the center. After serving as the director of External Relations and Business Development, she retired from NASA in August 2003.

Her numerous awards and recognition include induction into the Florida Women Hall of Fame, and recipient of the Kurt H. Debus Award, as well as two meritorious executive awards from President Bill Clinton in 1995 and 1998. In 2001, Florida Governor Jeb Bush appointed her one of the state's new



In the Firing Room at NASA's Kennedy Space Center on July 16, 1969, members of the launch team listen to congratulatory remarks by Vice President Agnew following the successful liftoff of Apollo 11. In the center of the photograph (see red arrow) is JoAnn Morgan, the only woman engineer among scores of male counterparts. Photo credit: NASA

university trustees, assigned to the University of Florida's Aerospace Engineering, University of Central Florida's College of Engineering and the University of West Florida's Institute for Human and Machine Cognition. She is a tireless advocate for women in science and engineering.

Though born in Huntsville, Alabama, Morgan grew up in Brevard County, Florida. She attended the University of Florida in Gainesville and earned a Bachelor of Arts in mathematics from Jacksonville State University in Alabama. She went on to earn a Master of Science in management from California's Stanford University.

"There have been many heroines in our nation's history who have broken down barriers with grit and determination, and persevered in the face of challenge," said Deputy Center Director Janet Petro. "During an era when most civil rights and equal rights called attention to our nation's struggle, the women of NASA were finding unique opportunities."

Petro said their persistence built hope for the future of their daughters and many of us here today. NASA has a longstanding legacy of inclusion, and its commitment to diversity in the

workplace is well recognized.

Petro cited the recent movie, "Hidden Figures," which focused on the experiences of Katherine Johnson, Dorothy Vaughn and Mary Jackson, three African-American women working as human computers during the early years of NASA's space program. They faced daunting challenges, but nevertheless, they persisted.

Forty years ago, in preparation for the space shuttle era, NASA selected six women to officially train among a new astronaut class, Astronaut Group 8. Among them were Sally Ride, Kathryn Sullivan and Shannon Lucid. Ride was the first U.S. woman astronaut in space. She broke through the ultimate glass ceiling, blasting into orbit on the space shuttle Challenger as part of the STS-7 crew on June 18, 1983.

Mae Jemison was the first African-American in space. She flew aboard space shuttle Endeavour on the STS-47 Spacelab J mission that launched Sept. 12, 1992. Sullivan was the first woman to perform a spacewalk, during STS-41G aboard space shuttle Challenger on Oct. 11, 1984. Lucid was the first U.S. woman astronaut on the Russian space station Mir. She launched aboard space shuttle Atlantis on STS-76 on March 22, 1996, the third



JoAnn Morgan, at right, keynote speaker during a Women's History Month event at NASA's Kennedy Space Center on March 27, speaks with Charlie Blackwell-Thompson, the first female launch director, who will lead countdown and launch for NASA's Exploration Mission-1. Photo credit: NASA/Leif Heimbald

***“The women who were first yesterday, opened doors for us as we enter into a new era of space exploration.”***

**– Janet Petro**  
Deputy Center Director

Shuttle/Mir4 docking mission. At the time, Lucid set the U.S. longest record of 188 days in space.

NASA astronaut Ellen Ochoa was the first Hispanic-American in space, when she launched on space shuttle Discovery's STS-56 mission on April 8, 1993. After retiring from NASA, her path led her to become director of the agency's Johnson Space Center in Houston.

NASA astronaut Peggy Whitson was the first female commander of the International Space Station. In 2017, Whitson clocked 665 days in space, more than any other American, and the most for any nationality.

“NASA's tradition of hiring incredible women continues at Kennedy Space Center,” Petro said. “Just when you think there are few records left to break, women are still breaking down barriers at NASA today.”

Today, Charlie Blackwell-Thompson is NASA's first female launch director. As the launch director for the agency's Exploration Ground Systems Program, Blackwell-Thompson will oversee the countdown and liftoff of the Space Launch System rocket and Orion spacecraft on its first uncrewed flight test, Exploration Mission-1. Recently, she led a firing room tanking simulation for the new EM-1 countdown procedures.

“I am honored to serve NASA as the center's first female deputy director,” Petro said. “Nearly 50 percent of Kennedy's management team are women.”

Joining her on the executive team are many accomplished female professionals. They are Barbara Brown, chief technologist; Amanda Mitskevich, Launch Services Program manager; Kathy Leuders, Commercial Crew Program manager; Josie Burnett, director of Exploration Research and Technology; Vanessa Stromer, Information Technology and Communications director; Nancy Bray, Spaceport Integration and Services director; Susan Kroskey, chief financial officer; Cheryl Hurst, Communications and Public Engagement director; and Digna Carballosa, Human Resources director.

Through the years, NASA and Kennedy have made concerted efforts to increase the number of women civil servants. In the 1980s, about 21.5 percent of Kennedy's civil servant workforce were women. Fast forward to 2018, and Kennedy's female civil servants represent 32.6 percent of the center's total workforce.

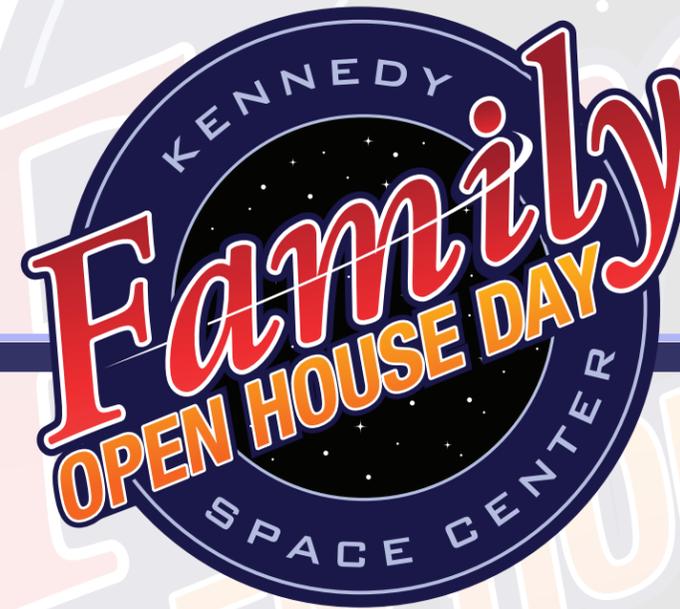
“The women who were first yesterday, opened doors for us as we enter into a new era of space exploration,” Petro said.



Sally Ride broke through the ultimate glass ceiling, blasting into orbit on the space shuttle Challenger as a member of the STS-7 crew on June 18, 1983. Ride was the first female NASA astronaut. Photo credit: NASA



Mae Jemison suits up for her flight aboard space shuttle Endeavour on the STS-47 Spacelab-J mission. Jemison serviced as a science mission specialist and was the first African-American woman in space. The mission launched Sept. 12, 1992. Photo credit: NASA



### Crowds Flock to Spaceport for Family Open House Day

An estimated 20,000 Kennedy Space Center employees, family members and guests attended Family Open House Day on April 14, to see the workings of the premier, multi-user spaceport. This year's event also was a celebration of NASA's 60th Anniversary.

"NASA's Kennedy Space Center is one of the most exciting places to work," said Center Director Bob Cabana. "The Family Open House Day gives us a chance to show off our workplace as we celebrate the agency's anniversary."

Many center facilities were open for an up-close look, such as the mammoth Vehicle Assembly Building, Launch Control Center and the Space Station Processing Facility. Experts were on hand to describe work that takes place in each area and answer questions. There were events for kids of all ages, including demonstrations in science, technology, engineering and mathematics, or STEM. An emphasis was placed on activities for children to encourage interest in becoming the next-generation of space explorers.

"I appreciate the efforts of the Kennedy Space Center Exchange and the many volunteers for their work putting on this event for the workforce," Cabana said.



# Our Refuge

NASA'S KENNEDY SPACE CENTER  
NATIONAL WILDLIFE REFUGE

Gopher tortoises are a familiar sight at NASA's Kennedy Space Center, munching on grass along the road's shoulders and occasionally crossing roads. In this edition of the "Our Refuge" series, we look at the gopher tortoise's biology and life history, and discover their place in the big picture of ecological diversity at Kennedy. Visit [Gopher Tortoise Council](#) and the Florida Fish and Wildlife Conservation Commission [gopher tortoise webpage](#) for more information.

## Why are they called gopher tortoises?

The gopher tortoise's real (Latin) name is *Gopherus polyphemus*. Polyphemus was the legendary cave-dwelling Cyclops from the "Iliad," and the name was chosen as the species designation in 1802. *Gopherus* was first used in 1816 to describe all North American tortoises. It is derived from the word gopher, which is commonly used to characterize burrowing animals.

## How long have gopher tortoises been around?

The gopher tortoise belongs to a group of land tortoises that originated in North America approximately 60 million years ago, making it one of the oldest known living species.

## Where do gopher tortoises live?

The historic geographic range of the gopher tortoise was the southeast coastal plain from the southwest tip of South Carolina to easternmost Louisiana, including Florida. Land development has fragmented the former range into many smaller parcels so that populations are no longer contiguous and are isolated from one another.



A gopher tortoise searches for food at the edge of a road near Kennedy Space Center's Launch Pad 39A. Photo credit: NASA/Ken Thornsley

## What kinds of habitats do they need?

Because they are burrowing animals, they require high, dry habitats such as scrub and scrubby flatwoods. They also feed in lower elevation areas that have an abundance of short grasses and herbs, so uplands and wetlands in close proximity provide excellent conditions. Gopher tortoises occur in large numbers along the Kennedy coastline as well, where the dune habitat is high, but supports low-growing herbaceous vegetation. Tortoises often are found in man-made environments around facilities, right-of-ways, and along roadsides where consistent mowing provides food.

## How long can they live?

Gopher tortoises can live up to 80 years in the wild and longer than that in captivity.

## What is a gopher tortoise burrow like?

The tortoise digs a burrow by pushing dirt behind it with its powerful front legs and claws, packing the dirt above and below with its shell. As it digs, the sand blasts out of the hole like a geyser. The tunnel goes into the ground at about a 45 degree angle and is typically 15 to 20 feet long, although they can be much longer, depending on the habitat and specific situation. The tunnel is usually straight or with slight curves, but can occasionally have sharp turns and even branches. At the end of the tunnel is a cavity just wide enough for the tortoise to turn around in, and there is only one way in and out.

## Why is the tortoise burrow such a big deal?

The burrow has many functions and each tortoise typically has several burrows within its home range. The burrow provides protection for the tortoise from weather, fire and predators. Because they are reptiles and cold-blooded, the tortoise can move up and down the burrow tunnel in order to find that perfect spot with the best temperature, allowing them to control their body temperature. Gopher tortoise burrows also provide shelter to more than 360 species of invertebrates and vertebrate wildlife, several of which are federally listed (e.g., eastern indigo snake and southeastern beach mouse). Because of the importance of the burrow to an entire community of species, the gopher tortoise has been called a "keystone species," indicating that when tortoises disappear from an area, the entire ecosystem is changed, and not for the better.



A turtle lumbers along on the sand near railroad tracks at Kennedy Space Center. Photo credit: NASA/Bill White

## Are they legally protected?

Gopher tortoises are legally protected throughout their range. In Florida, South Carolina, Georgia and most of Alabama, they are protected by state regulations as a Threatened species. In Louisiana, Mississippi and westernmost Alabama, they are listed as Threatened under the Endangered Species Act (ESA). In 2011, the U.S. Fish and Wildlife Service added gopher tortoises from the entire range to the list of Candidate species for eventual protection under the ESA.

State and federal regulations make it illegal to kill, injure, relocate, keep or interfere with tortoises or their burrows in any way (even providing food or water). This protection includes actions of children and pets. If you observe tortoises or burrows being harmed by development or individuals, please call the Florida Fish and Wildlife Conservation Commission wildlife hotline at 888-404-3922. You can remain anonymous.

## Am I breaking the law if a tortoise is living in my yard or on my property?

If the tortoise is there of its own accord and you are not hindering its movement or preventing it from leaving, not only are you within the law, you are lucky!

## What should I do if I see an injured tortoise on Kennedy Space Center?

Please immediately call the Duty Office at 861-5050. They will contact the appropriate people to take care of the situation.



## 55th Anniversary: Gordon Cooper's 22-orbit Mercury flight

On May 15, 1963, 55 years ago this month, NASA astronaut Gordon Cooper lifted off atop an Atlas rocket from Launch Complex 14 at Cape Canaveral Air Force Station. The day-and-a-half flight concluded Project Mercury and marked the last time an American astronaut would launch to space alone.

Aboard the Mercury spacecraft he named "Faith 7," Cooper extensively photographed the Earth and was the first American to sleep in space. He explained that he put his hands under the strips on his spacesuit so they would not inadvertently bump a switch on the instrument panel.

During the 34-hour, 19-minute flight, "Faith 7" orbited Earth 22 times, traveling 600,000 miles. Cooper landed just four miles from the prime recovery ship, the USS Kearsarge. He elected to remain in the spacecraft until it was hoisted to the aircraft carrier deck and was assisted out of his spacecraft by recovery crews. Photo credit: NASA

National Aeronautics and Space Administration

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