

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



**Prepping for Orion Water Recovery Test**

# KENNEDY SPACE CENTER'S SPACEPORT MAGAZINE CONTENTS

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**Cover:** U.S. Navy divers are training in the Neutral Buoyancy Laboratory at NASA's Johnson Space Center in Houston. Navy divers, Air Force pararescuemen and Coast Guard rescue swimmers practice Orion underway recovery techniques using a test version of the Orion spacecraft. Training will help the team prepare for Underway Recovery Test 5 for Exploration Mission 1 aboard the USS San Diego in the Pacific Ocean off the coast of California in October. The Ground Systems Development and Operations Program, along with the U.S. Navy are preparing the recovery team, hardware and operations to support EM-1 recovery. Photo credit: NASA/James Blair

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## NASA'S LAUNCH SCHEDULE

**Date:** Nov. 15, 4:05 p.m. EDT  
**Mission:** Expedition 50 Launch  
**Description:** NASA astronaut Peggy Whitson, cosmonaut Oleg Novitskiy of the Russian space agency Roscosmos and European Space Agency astronaut Thomas Pesquet will launch to the space station aboard the Soyuz MS-02 spacecraft from the Baikonur Cosmodrome in Kazakhstan.

**Target Date:** Nov. 16  
**Mission:** Geostationary Operational Environmental Satellite-R Series (GOES-R)  
**Description:** The advanced spacecraft and instrument technology used on the GOES-R series will result in more timely and accurate forecasts and warnings.  
<http://go.nasa.gov/1YubP2g>

**Date:** Dec. 1  
**Mission:** Progress 65 Launch  
**Description:** The Russian Progress 65 cargo craft will launch to the International Space Station from the Baikonur Cosmodrome in Kazakhstan on a two-day trip to the International Space Station, delivering food, fuel and supplies.  
<http://go.nasa.gov/2eSngvM>

**Date:** Dec. 9, 8:26 a.m. EST  
**Mission:** HTV-6 Cargo Craft  
**Description:** Launch of the Japan Aerospace Exploration Agency (JAXA) H-II Transfer Vehicle (HTV) unmanned cargo transfer spacecraft from Tanegashima, Japan. HTV-6 "KOUNOTORI6" will deliver supplies to the International Space Station.  
<http://go.nasa.gov/2eSn3P>

**Date:** Dec. 12  
**Mission:** Cyclone Global Navigation Satellite System (CYGNSS)  
**Description:** Launching from Cape Canaveral Air Force Station, Florida, on a Pegasus XL rocket, the CYGNSS mission will probe the inner core of hurricanes to learn about their rapid intensification.  
<http://www.nasa.gov/cygnss>

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# KENNEDY SPACE CENTER

## DAVID RAMSEY

I am the chief of Flight Operations for NASA's Kennedy Space Center. As such, I am the senior line manager over flight activities operated or controlled at Kennedy and directly responsible to Center Director Bob Cabana for the safe and effective conduct of those activities.

I am also an aircraft commander of Kennedy's Bell Huey II helicopters which have the primary responsibilities of providing program support to security, environmental research, contingency operations, launch security, and numerous other center-supporting roles.

Additionally, my office oversees the use of small Unmanned Aircraft Systems at Kennedy. These systems are taking an ever-increasing role in providing data during emergency or contingency operations, during natural disaster events, and in the surveying of the infrastructure required to perform our mission here at Kennedy.

I am a recently retired, 21-year Army veteran who relocated from Washington, D.C., to Central Florida for the opportunity to work at NASA. Leaving the comradery of the military was a difficult decision, but after six months here at Kennedy, I can now say that it was a great decision. The teamwork and enthusiasm for the work being accomplished here is reminiscent of my military days and I'm proud to be a part of the team! Go Army, beat Navy . . . (if you say it often enough, perhaps it will happen . . . someday)



# PREPARING FOR UNDERWATER RECOVERY TEST 5



## Divers practice Orion water recovery techniques in giant pool

BY LINDA HERRIDGE

A group of U.S. Navy divers, Air Force pararescuemen and Coast Guard rescue swimmers practiced Orion open water recovery techniques Sept. 20-22 in the Neutral Buoyancy Laboratory (NBL), the largest indoor pool in the U.S., at NASA's Johnson Space Center in Houston. They were preparing for the first test flight of an uncrewed Orion spacecraft with the agency's Space Launch System rocket, known as Exploration Mission 1 (EM-1).

When Orion returns from deep space missions and lands in the Pacific Ocean, a team of military and NASA personnel will be responsible for safely returning the capsule back to land. The team is evaluating tools and procedures they will use to tow the spacecraft into the well deck of a U.S. Navy ship.

Construction began on the 6.2-million-gallon NBL in 1995 and was operational in 1996. It was built specifically for International Space Station size mockups. Its predecessor, the Weightless Environment Training Facility, was built in the 1960s for testing procedures, developing hardware and training astronauts. The current facility is primarily used to train astronauts for spacewalks aboard the International Space Station, but also has been used to help prepare for Orion recovery operations.

During the evaluations, a test version of the Orion spacecraft was lowered into the water in the NBL. Divers used inflatable zodiac boats to easily steer to the test spacecraft. The team trained on how to inflate and secure the stabilization collar around the crew module. For a crewed mission, the collar will serve as a place to stand on to recover astronauts and assist them out of the capsule.

U.S. Navy master diver Michael Hunt served as the technical expert for the team and was responsible for overall safety during training. He has been a diver for 23 years and is with the Explosive Ordnance Disposal Unit 3 in the Mobile Diving Salvage Co. stationed at the Coronado Naval Amphibious Base in California.

"Everyone on the team goes out of their way

U.S. Navy divers, Air Force pararescuemen and Coast Guard rescue swimmers practiced Orion recovery techniques Sept. 21 at the Neutral Buoyancy Laboratory (NBL) at the agency's Johnson Space Center in Houston. The recovery team used a test version of the Orion crew module. Training helped the team prepare for Underway Recovery Test 5 for Exploration Mission 1 aboard the USS San Diego in the Pacific Ocean off the coast of California beginning in late October. Photo credit: NASA/James Blair



Tim Goddard, center, Open Water Recovery Operations test conductor with Raytheon Technical Services, briefs U.S. Navy divers, Air Force pararescuemen and Coast Guard rescue swimmers during training in the Neutral Buoyancy Laboratory at NASA's Johnson Space Center in Houston. The group practiced Orion underway recovery techniques using a test version of the Orion spacecraft. Photo credit: NASA/James Blair

to be helpful, and it is a privilege and honor to be a part of this NASA mission," Hunt said.

Training at the NBL will help the team prepare for Underway Recovery Test 5 (URT-5) later this fall, which will be the first major integrated test in a series of tests to prepare the recovery team, hardware and operations to support EM-1 recovery using a U.S. Navy ship. The term "underway" refers to recovery tests done when a ship is at sea.

Training for URT-5 included first time use and training of new capsule attachment hardware developed by NASA as part of a research and development project. After a flotation collar was placed around Orion, divers practiced attaching the tow lines to modified tow cleat assemblies on the crew module. The tether lines were used to simulate towing Orion into the well deck of a Navy recovery ship.

"The biggest challenges for the team will be weather and sea conditions during Orion underway recovery operations in the Pacific Ocean," Hunt said.

The tow cleats were modified to include a tow pin insert that allows easier tow line connections in the rocky waves of the open ocean. One end of the tow pin inserts and locks into place in the tow cleat, and the other end connects to the winch or tending lines. Also, for EM-1, Orion will have five attach points; two more than were on the crew module for Exploration Flight Test-1 in December 2014.

The divers, and engineers with NASA's Ground Systems Development and Operations Program at Kennedy Space Center, practiced Orion recovery techniques and aboard the USS San Diego in the Pacific Ocean off the coast of California in October.

"URT-5 will be instrumental in gathering loads data for the new design and determining the final design of our recovery system in the future," said Melissa Jones, GSDO URT-5 Landing and Recovery director. "Training in the NBL in a controlled environment will ensure the success of open water operations during URT-5."

During EM-1, Orion will travel about 40,000 miles beyond the moon and return to Earth after a three-week mission. Orion will travel through the radiation of the Van Allen Belts, descend through Earth's atmosphere and splash down in the Pacific Ocean.

#### Orion Service Module Umbilical Testing Wraps Up at Launch Equipment Test Facility

Testing of the Orion Service Module Umbilical (OSMU) is complete at the Launch Equipment Test Facility at Kennedy Space Center. A series of tests, called regressions tests, were performed on the umbilical's design modifications to validate it for installation on the mobile launcher. The tests were conducted by Kennedy's Engineering Directorate for the Ground Systems Development and Operations Program.

During the tests, the OSMU was connected to the facility's Vehicle Motion Simulator 1 and the umbilical's release mechanism that will connect to the service module was tested to confirm it is functioning properly.

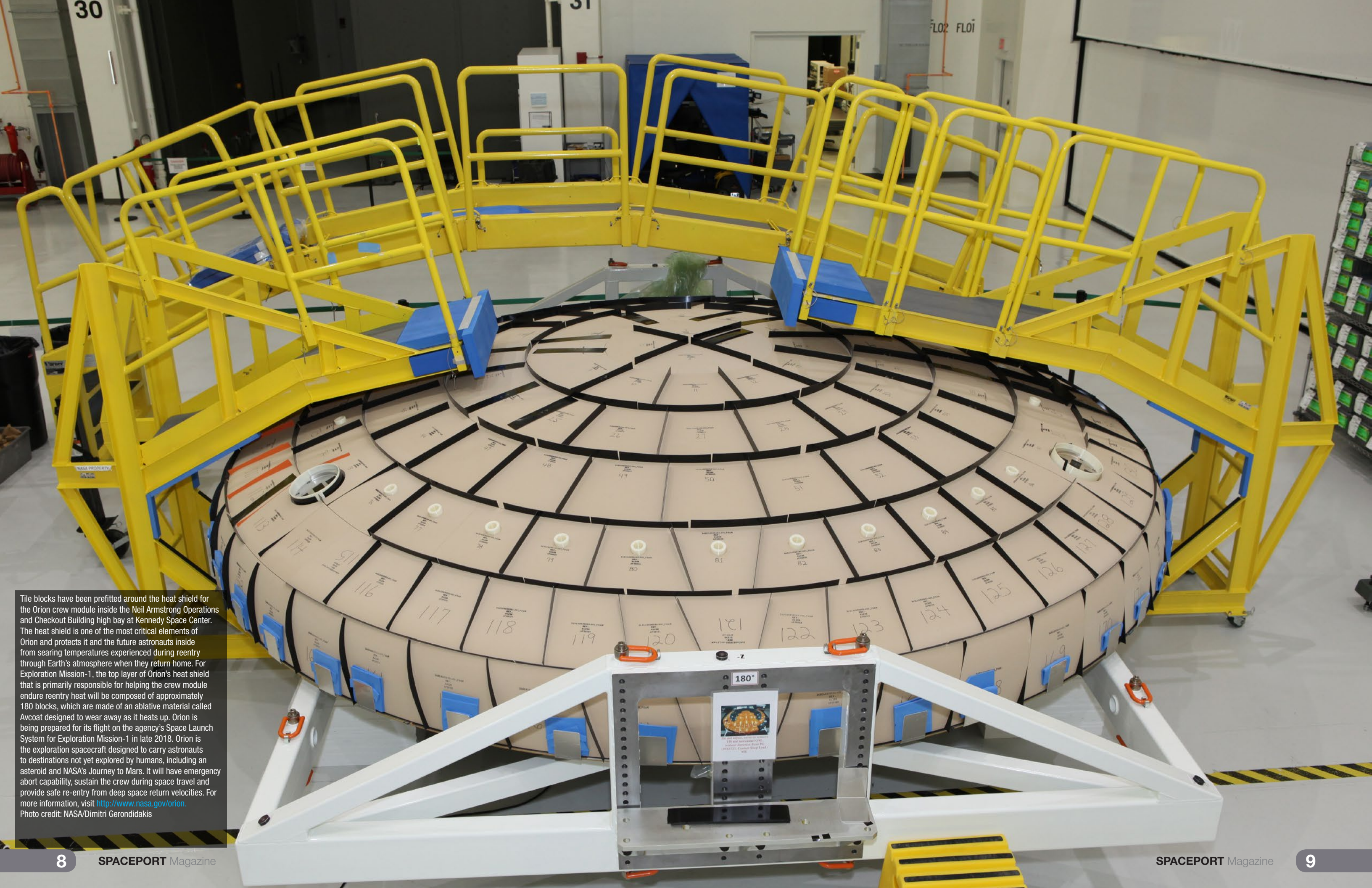
The OSMU will connect from the mobile launcher tower to the Orion service module at about the 280-foot level of the mobile launcher tower. Prior to launch, the umbilical will transfer liquid coolant for the electronics and air for the environmental control system to the Orion service module that houses these critical systems to support the spacecraft. The OSMU also will provide purge air and gaseous nitrogen for environmental control to the Launch Abort System located atop the spacecraft. The OSMU will release and tilt back, away from the service module, before launch.

NASA's Space Launch System (SLS) will launch with the Orion spacecraft atop for its first flight in 2018. The SLS is the rocket that will carry Orion to deep space destinations, including the agency's Journey to Mars.

Photo credit: NASA/Ben Smegelsky



The test team gathered with a special banner during an event Oct. 19 to mark the end of testing. Photo credit: NASA/Ben Smegelsky



Tile blocks have been prefitted around the heat shield for the Orion crew module inside the Neil Armstrong Operations and Checkout Building high bay at Kennedy Space Center. The heat shield is one of the most critical elements of Orion and protects it and the future astronauts inside from searing temperatures experienced during reentry through Earth's atmosphere when they return home. For Exploration Mission-1, the top layer of Orion's heat shield that is primarily responsible for helping the crew module endure reentry heat will be composed of approximately 180 blocks, which are made of an ablative material called Avcoat designed to wear away as it heats up. Orion is being prepared for its flight on the agency's Space Launch System for Exploration Mission-1 in late 2018. Orion is the exploration spacecraft designed to carry astronauts to destinations not yet explored by humans, including an asteroid and NASA's Journey to Mars. It will have emergency abort capability, sustain the crew during space travel and provide safe re-entry from deep space return velocities. For more information, visit <http://www.nasa.gov/orion>. Photo credit: NASA/Dimitri Gerondidakis

# HURRICANE MATTHEW

Assessments and repairs are in progress at various structures and facilities across the spaceport, part of the ongoing recovery from Hurricane Matthew, which passed to the east of Kennedy on Oct. 6 and 7. The center received some isolated roof damage, damaged support buildings, a few downed power lines, and limited water intrusion. Beach erosion also occurred, although the storm surge was less than expected. Photo credit: NASA



A damaged construction trailer and several pieces of associated debris, aftermath of Hurricane Matthew, are seen near the Mobile Launcher in the Launch Complex 39 area



A beach area



The Beach House



Hurricane Matthew tore away a section of wall on a support building in the Launch Complex 39 area.



The roof of the Operations Support Building I



Siding damage caused by Hurricane Matthew is seen inside a support building in the Launch Complex 39 area.



**OPPORTUNITIES EXPO**

Hundreds of businesses and government exhibitors were on hand Oct. 25 to share ideas, information and opportunities at the NASA/KSC Opportunities Expo 2016 at Port Canaveral, in Florida. A variety of product and service areas from across the nation were on display at the event, in its 26th year. Photo credit: Dimitri Gerondidakis

# CUTTING EDGE

## Kennedy's chief technologist talks innovation

BY BOB GRANATH

Innovation is defined in the dictionary as the act or process of introducing new ideas, devices or methods. For more than five decades, Kennedy Space Center has been the epitome of innovation as technologies have evolved, new destinations have been charted, and the paradigm has shifted in how the agency works with private partners.

For employees at the multi-user spaceport, innovation takes on many different meanings.

"Innovation to me is coming up with a new idea and running with it," said Raewyn Duvall, a computer engineer in Kennedy's Spaceport Systems Branch.

"Innovation is how we can help make the government more efficient, how we continue to use technology to make progress in our lives and make the future better for everyone," said Josh Johnson who works in Kennedy Software Systems in Ground Systems Development and Operations.

According to Kennedy's chief technologist, Karen Thompson, fostering new initiatives is a job for everyone.

"We want to help our people further their ideas for improvements," she said. "One way we do that is with the KickStart competition at our Innovation Expo where employees submit innovation concepts and proposals.

Those selected are pitched in 90 seconds before an audience and a panel of judges. The program has proved to be a valuable tool to help employees implement their ideas for improving work in all areas at Kennedy."

Thompson noted KickStart at Kennedy is gaining interest agencywide.

"Our agency innovation day Nov. 1 included a NASA Innovation KickStart (NIKS) borrowed from our Kennedy event," she said. "Leaders at the Marshall Space Flight Center in Huntsville, Alabama, are among those at other centers who are looking at what we do here to encourage their employees through a similar event."

This year there were two different KickStart competitions Nov. 1. The first being the Kennedy KickStart and the second a NIKS Live. Each included a competition of innovation proposals with a small amount of funding awarded to the winners allowing them to procure items needed for their projects. The competition is an opportunity for innovators to receive up to \$5,000 in the Kennedy event and up to \$10,000 in the agency competition to implement their winning suggestions.

Thompson noted that coming up with new ideas used to begin predominately with one person working "off in a corner."

"Then we began encouraging small groups from different areas, representing varied disciplines, getting together to brainstorm," she said. "Kennedy employees have always done a great job working in collaborative teams with one another, as well as with partners from other centers, other

Photo credit: NASA/Dan Casper

agencies, industry and academia. We always encourage employees to look for ways to do their work better and to propose concepts for tackling future mission needs."

Those innovative efforts led to the formation of Spaceport Innovators. The group has grown to about 500 members who



An integrated test of the MARCO POLO/Mars Pathfinder in-situ resource utilization, or ISRU, system takes place at NASA's Kennedy Space Center in Florida. Photo credit: NASA/Dimitri Gerondidakis

review the way things are done at Kennedy, encouraging groups to come up with new ideas for solving problems and being more efficient and finding innovative methods used by individuals and groups elsewhere.

"Kennedy often collaborates with other NASA centers to draw off their strengths," Thompson said. "While we are the nation's premier multi-user spaceport, we may team with the Jet Propulsion Laboratory with expertise in planetary exploration and together develop concepts for future human destinations."

Those at the Florida spaceport also have been sought out for ideas for improvements.

"Owners of payloads to be launched here frequently seek advice from our experts," said Thompson.

While innovation is frequently viewed as developing new technology, Thompson explains it is much more.

"It can be about new processes," she said. "It also can be about developing ways for cost savings."

In recent years, Kennedy's Swamp Works has focused on that approach. The laboratory has used "lean management" concepts to develop exploration mission solutions while taking advantage of partnerships across NASA.

The lean management approach for research and technology (R&T) is designed to build a little, then test a little, then immediately apply what is learned to quickly incorporate into the R&T project to achieve successful technology development



Morgan Simpson displays concepts for inducing artificial gravity on plant growth experiments. Photo credit: NASA/Bill White

much quicker than when using more traditional methods. Such a management approach also provides an organization with continuous improvement, a long-term approach to systematically look for ways to achieve small, incremental changes in processes that improve efficiency and quality.

Thompson noted that a robot called RASSOR, for Regolith Advanced Surface Systems Operations Robot, is an example of the developments of the scientists and engineers at the Swamp Works.

"The robot is designed to mine regolith on a planetary body such as Mars," she said. "That mining will allow us to collect loose surface soil that can be processed to create water, hydrogen and oxygen, while also cleaning areas for launch and landing pads."

But the efforts in developing RASSOR will go beyond its original design.

"The technology concepts we are developing now will help in designing the next generation of robots," Thompson said.

Morgan Simpson of the Environmental and Life Support Systems Branch of Kennedy Engineering is working on another innovation — a way to grow plants in microgravity during long spaceflights using a rotating wheel.

"Our project is called VeggieGoRound," he said. "It will create artificial gravity to improve processes to provide water and oxygen to plants' root systems."

In encouraging innovation for future projects, Kennedy managers do not want employees to be afraid of setbacks.

"Throughout the agency, for low technology readiness level projects, we encourage pushing the technology 'envelope' and working on the cutting edge," Thompson said.

Failure is not an option during a mission. However, during the early phases of research and development, Thompson believes setbacks are part of the learning process.

"If you never have a technology failure on an early research project now and then, you may not be pushing the 'envelope' far enough," she said. "Employees are always encouraged to step up and suggest ways to work better and improve all areas of work here at Kennedy."

**"If you never have a technology failure on an early research project now and then, you may not be pushing the 'envelope' far enough."**

— Karen Thompson, NASA's Chief Technologist at Kennedy Space Center



# STARLINER SIM

Trainers prepare NASA's astronauts, flight controllers for the next era of human spaceflight

BY NOAH MICHELSON  
NASA'S Johnson Space Center

Suddenly, you're barreling down toward Earth at speeds 10 times faster than a bullet, headed straight for Earth — but all the nerves are gone. You've landed this flight 100 times before.

Nearly 250 miles below, hallways within NASA Johnson Space Center's Jake Garn Mission Simulator and Training Facility are lined with history. Since 1965, the facility, known to Johnson team members simply as Building 5, has trained the world's greatest explorers for Gemini, Apollo, Space Shuttle and International Space Station Program missions.

Building 5 is now home to a new innovation—the Crew Part-Task Trainers—which are spaceflight training simulators for Boeing's CST-100 Starliner spacecraft. The Starliner trainers will prepare NASA's astronauts and flight controllers for the next era of human spaceflight with Starliner's first crew launch to the International Space Station targeted for 2018.

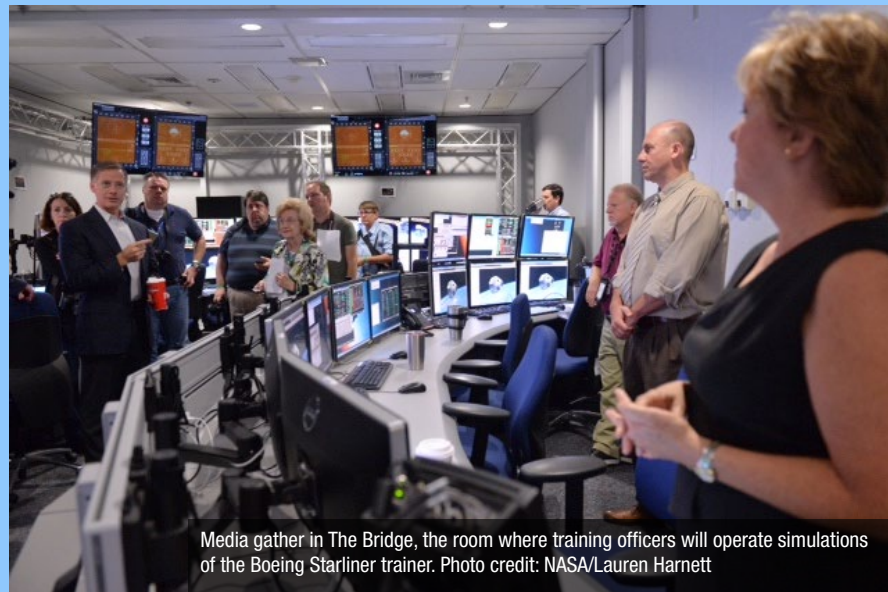
The goal of NASA's Commercial Crew Program (CCP) is to return human spaceflight launches to U.S. soil, providing reliable and cost-effective access to low-Earth orbit on systems that meet the agency's stringent safety requirements. To accomplish this goal, NASA is taking a unique approach by asking private companies, Boeing and SpaceX, to develop new spacecraft to provide reliable transport of astronauts to and from the space station.

The Starliner Crew Part-Task Trainers, each a scale replica of the spacecraft's control area, create a realistic simulation of spaceflight for comprehensive training. The trainers use technology similar to F-15 simulators that Boeing developed for the U.S. Air Force.

Rather than having rigid panels stretching over several positions and housing row upon row of switches, dials and readouts, as on the Apollo spacecraft and space shuttle, Starliner crews will rely on screens, about two dozen physical buttons and switches and a joystick. NASA CCP astronauts had the opportunity to offer input into the design of the trainers to help tailor the simulation for spaceflight.

"The simulation can be amazingly close to actual flight,"

said NASA Flight Director Robert Dempsey, who is a member of the Starliner Flight Operations team. "It's never going to be precisely how it is in space, but once we start receiving data from the simulator and the crew, our process mimics actual flight very closely."



Media gather in The Bridge, the room where training officers will operate simulations of the Boeing Starliner trainer. Photo credit: NASA/Lauren Harnett

The simulated process begins with flight controllers writing procedures for each stage of the mission. From there, crew trainers in Building 5 identify potential failures that could arise during spaceflight and use them to challenge the crew and flight controllers during training.

"They might throw in a computer failure, a fire or a power failure that wipes out half of the systems," Dempsey said. "We joke that the trainers are these evil geniuses who stay up at night planning how to trick us."

These failures may be simulated, but Dempsey emphasized that emotions during a simulation are everything but.

"When I'm making a decision, it is very much on my mind that a wrong choice could kill the crew," Dempsey said. "It's simulated, but it's not role playing. This isn't 'Dungeons and Dragons.'"

Pete Meisinger, Boeing's program manager for Space Vehicle



Sunita Williams takes the helm at the Crew Part-Task Trainer, which simulates Boeing's CST-100 Starliner Spacecraft. Photo credit: NASA/Lauren Harnett

***"They might throw in a computer failure, a fire or a power failure that wipes out half of the systems. We joke that the trainers are these evil geniuses who stay up at night planning how to trick us."***

**— Robert Dempsey  
NASA Flight Director**

Training Programs, said the devices his team installed at Johnson are designed to prepare astronauts and flight controllers for any situation that could arise in the harsh environment of space.

"We have been working hand in hand with NASA for quite some time to ensure the devices at Johnson will deliver the highest level of training fidelity possible," Meisinger said. "It is critical to us that the NASA team is prepared for the entire set of experiences it will encounter during a successful mission, and is ready to identify and resolve issues no matter how unlikely they are to occur."

A huge benefit of virtual training is that even if the exact same problem doesn't arise during spaceflight, the skills have been engrained so that the astronauts and flight controllers have the right mindset to identify problems that may appear and solve them.

"When you're out there, you have to feel prepared," said NASA astronaut Sunita Williams, one of four astronauts selected to train for the first CCP spaceflights. "You have to get on the spacecraft knowing that all that other stuff is already taken care of."

Simulations for the uncrewed Starliner flight test is scheduled to begin later this year at Johnson. The next step afterward will be to transition to crewed training in preparation for the first crewed launch of the Starliner spacecraft, slated for 2018.

When we look back on the last 50 years of human spaceflight, it is clear that training simulators have prepared astronauts and flight controllers for many obstacles. This next generation of trainers will make sure we are ready for any obstacle space throws our way.

# I Will LAUNCH AMERICA

Restoring America's Human Launch Capability



**Mike Ravenscroft**  
Launch Site Integration Lead  
NASA's Commercial Crew Program

## I Will Launch America: Mike Ravenscroft

BY STEVEN SICELOFF

Every astronaut who flies into space should go with the confidence that every detail of their spacecraft, rocket and mission has been thought-through and evaluated carefully, engineer Michael Ravenscroft said. That's one of the reasons that the Commercial Crew Program engineer takes so little for granted as the program steers itself and partners toward a new dawn of human spaceflight from American soil.

"It's one of those things you always think about — you don't want to put anybody at unnecessary risk," Ravenscroft said.

Ravenscroft worked on the space shuttles and expendable rockets before joining NASA's Commercial Crew Program, where he serves as the launch site integration lead working with Boeing and United Launch Alliance. He said that the knowledge that astronauts will depend in part on his work being correct sparks his drive for perfection.

"Everybody sees the astronauts from afar," Ravenscroft said. "When we see them, they are the best of the best, but they also are people like the rest of us and when you talk to them and see what their interests are, why they are in commercial crew, you think, 'This is why I do this.' If I were the one getting strapped into the spacecraft, this is what I'd want everyone to be doing."

Engineering was Ravenscroft's first calling, not necessarily space. Growing up in western Pennsylvania with a father who worked the mines and a high school class of 50 people, Ravenscroft said he didn't get much exposure to space. That was for students in Florida, Texas and California, he said.

"I had a teacher who got me interested in engineering in general," Ravenscroft said.

He had an interest in chemical engineering at first, which would later turn into a passion for aerospace engineering, which he would later use as a shuttle propulsion system engineer.

"Throughout that learning process, I transitioned from engineering to aerospace engineering," Ravenscroft said. "I believe that I am making history. Commercial crew is going to launch astronauts from Florida and some of these things we are working on now — these spacecraft, missions and designs — are going to be celebrated in museums and science exhibits before long."

Ravenscroft said the unique nature of commercial crew is exciting, because it is being performed in a tight partnership between the agency and aerospace companies Boeing and SpaceX. Both Boeing and SpaceX are building separate spacecraft and launch systems, along

with their own unique launch pads at Kennedy and the adjacent Cape Canaveral Air Force Station in Florida.

Instead of NASA dictating designs and owning the spacecraft, NASA is overseeing design and production and then buying the services from the companies to take astronauts to the International Space Station in order to enhance research there and to provide additional human launch capability from American shores.

"My personal opinion is, this is an opportunity to allow private industry to show what they can do," Ravenscroft said. "We've given the companies requirements, but we've let them show how they can perform and answer the requirements. We have not forced them into a design we think they should have — we want them to innovate. It also allows them to achieve their own goals, which I believe is going to help sustain the industry."

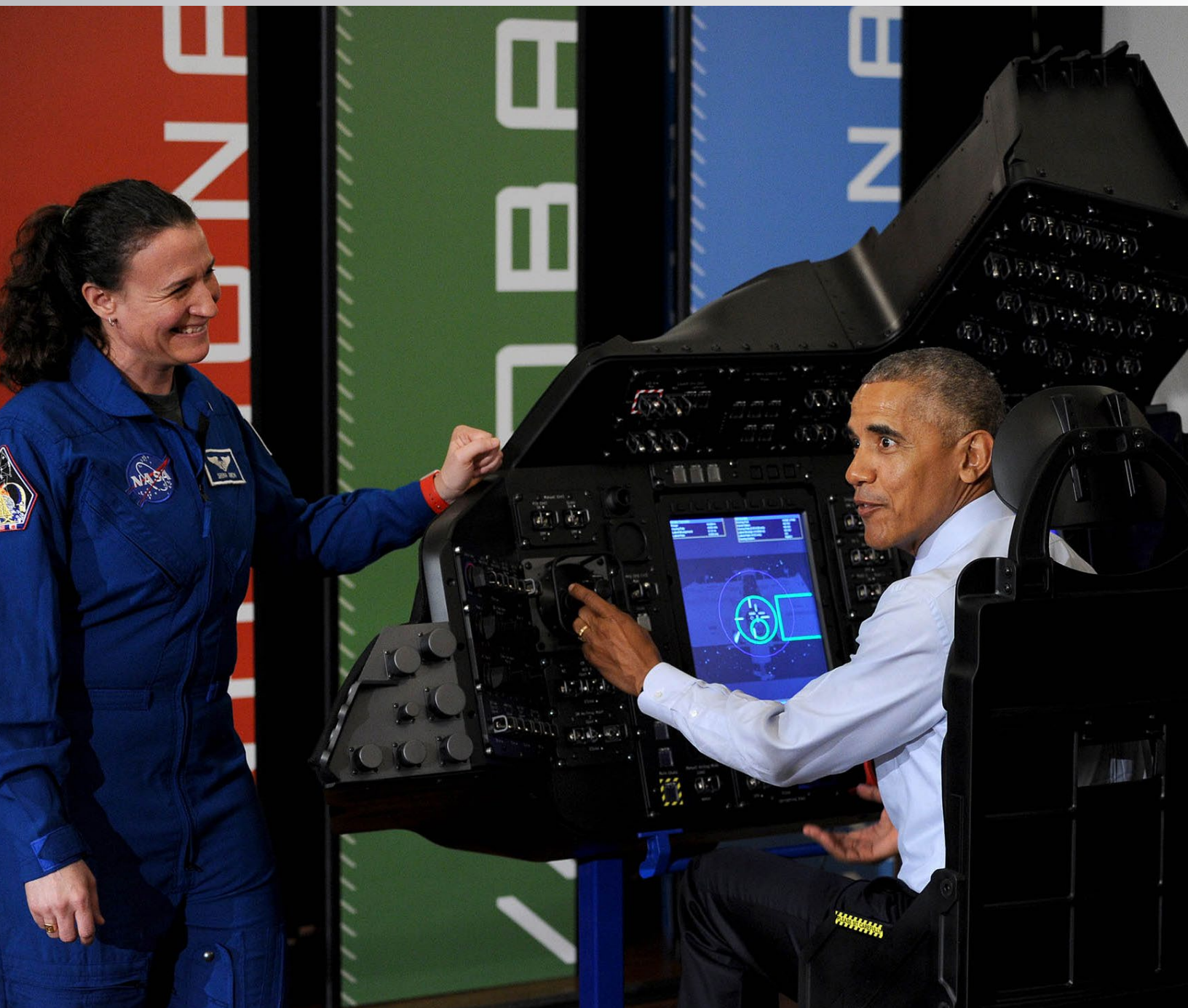
Working with Boeing and ULA at Space Launch Complex 41 has given Ravenscroft a close look at a metamorphosis. The launch complex is an historic landmark in spaceflight, because it was where the Viking landers bound for Mars lifted off from in 1976, the Voyager spacecraft departed Earth in 1977 to tour the outer planets, and the New Horizons probe started from on the first trip to survey Pluto.

However, none of those spacecraft required the same unique infrastructure of launch pads hosting human spaceflight missions. So, between regular Atlas V missions, construction crews assembled a 200-foot-tall tower at the pad one module at a time to create a structure complete with all the fittings to give astronauts and ground support crews access to Boeing's CST-100 Starliner spacecraft as it stands atop an Atlas V rocket on launch day.

"Once you start seeing that hardware come together and see things produced, that's when it starts to feel like things are real," Ravenscroft said. "This is when you say, 'This is not just an idea, we're building stuff and we're getting ready to launch from Florida.'"

Ravenscroft knows there are many more days of hard work ahead for him and the Commercial Crew Program teams. It won't even be over after the launch of the first commercial crew mission.

"I don't know when I'm going to cheer," Ravenscroft said. "I know I'm going to cheer, but I don't know when that is. The thing is, the mission's not done until they land. Then when they're stepping out of that spacecraft and wave their hands and say we've made it, then we'll know that all we worked on, and that all the partners did, worked."



## PRESIDENT TOUTS ADVANCES IN COMMERCIAL CREW SPACECRAFT

In case you missed it, President Barack Obama talked Oct. 13 with the two companies developing the next generation of American spacecraft designed to take NASA astronauts into orbit and to the International Space Station.

Touring exhibits by Boeing and SpaceX during the Frontiers Conference at Carnegie Mellon University and University of Pittsburgh in Pittsburgh, Obama discussed the immediate future of space exploration and touted the advances made in the public-private partnerships between the companies and NASA's Commercial Crew Program. Because the new spacecraft will enable a larger space station crew and more research time in space, they are seen as critical avenues to help scientists and astronauts explore the best methods to send crews into deep space and eventually to Mars.

The goal is "to lead humanity farther out into the final frontier of space," the president said. "Not just to visit, but to stay."

Obama even took the controls of a simulator designed to mimic the flight of Boeing's CST-100 Starliner spacecraft. He conducted a Starliner docking maneuver similar to the one astronauts will actually fly in the future during crew rotation missions to the

orbiting laboratory.

"Your ride is here," Obama said after completing the exercise.

"I'm not sure who had more fun today – the president or me," said NASA astronaut Serena Aunon-Chancellor, who helped demonstrate how the simulator worked. "He was a natural docking the Starliner to the space station!"

The president also inspected SpaceX's Crew Dragon design up-close and talked at length with Aunon-Chancellor and a company official.

"You almost want to get in and take off, don't you?" the president said.

"While visiting Dragon, we discussed the future of human spaceflight and how important it is to safely and reliably get our crew to the station in low-Earth orbit so NASA can focus on human exploration in deep space," Aunon-Chancellor said. "We're excited about the progress our partners are making and look forward to flying with them soon."

PHOTOS COURTESY OF MICHAEL HENNINGER/  
PITTSBURGH POST-GAZETTE

# HIGH GOALS

## CASIS forges new partnerships, launches new facilities to U.S. National Laboratory on International Space Station

BY FRANK OCHOA-GONZALES



The International Space Station serves as the world's leading laboratory for conducting cutting-edge microgravity research, and is the primary platform for technology development and testing in space to enable human and robotic exploration of destinations beyond low-Earth orbit, including asteroids and Mars. Photo credit: NASA

The Center for the Advancement of Science in Space (CASIS) is the organization tasked by NASA to manage the U.S. National Laboratory on the International Space Station (ISS). Our responsibilities range from selecting research to manifest, fly and be experimented on the orbiting laboratory. We also brainstorm (or develop) unique and creative ways to engage the public on this unique platform for innovation.

One of the other roles of the organization is to increase funding for research and other activities each year to manage the ISS National Lab. There are a few methods to achieving this goal of new funds: donations from the public-at-large or reaching out to organizations and other government organizations to fund investigations that are applicable to their research priorities. In fact, the past few months marks a critical point in the history of CASIS partnerships with other government agencies, as CASIS announced the progression of collaborations with both the National Science Foundation (NSF) and the National Center for Advancing Translational Sciences (NCATS), which is part of the National Institutes of Health (NIH). These prominent science organizations recognize the exceptional value of the ISS National Lab and are working hand-in-hand with CASIS to support research that utilizes our nation's unique orbiting laboratory for the benefit of life on Earth.

In both of these partnerships, CASIS and NASA facilitate the hardware implementation and in-orbit access to the ISS National Lab, while NSF and NCATS provide funding to support selected projects that will use the microgravity environment on the ISS to advance research that will have direct terrestrial benefit. Combined, both of these organizations plan to invest more than \$15 million in research aboard the station. To give you an idea on how impactful these relationships will be for CASIS moving forward, note that CASIS receives three million dollars from NASA for research each year. So these sponsored programs from the NSF and NIH will bring a litany of funding for

research focused on life and physical sciences.

However, CASIS is also in the business of launching payloads to the station on behalf of the ISS National Lab, and October marked Wallops Island's return to the industry after the successful launch and berthing of Orbital ATK's sixth contracted commercial resupply mission.

While typically CASIS is focused heavily on sending research to station, there is also a critical need to continuously update the laboratory to attract users and demonstrate the station is not only a unique platform for innovation, but also one with all the "bells and whistles" of Earth-based labs. This launch focused heavily on updating research facilities for the users of tomorrow. For instance, one payload that is now on station is the Controlled Dynamics Locker. Think of having an important item in a box while you drive your car. A lot can make that item move and shift while the car equally moves and shifts. The space station is no different, traveling at 17,500 mph. The Controlled Dynamics Locker ensures that research remains stable in its place, allowing for optimal results in scientific studies like protein crystal growth, where it is imperative that these crystals have no movement to grow at the rate needed to enhance discovery. Additionally, facilities have been added to the Solidification Using a Baffle in Sealed Ampoules (SUBSA) to reduce thermal convection for physical science payloads. Commercial partner NanoRacks is offering researchers more opportunities to leverage their ISS internal rack space with the Black Box, which is specially designed to provide near-launch payload turnover of autonomous payloads while providing advanced science capabilities for customers, including the use of robotics, new automated MixStix, and NanoLab-style research.

Altogether, the past few months have been highly busy for CASIS and the ISS National Lab. Expect more great announcements and research to launch to station in the coming months.

For more information about the ISS National Lab, go to <http://go.nasa.gov/2eWaEDR>.

# GROWING INTEREST

## Students plant seeds to help NASA farm in space

BY STEVEN SICELOFF

NASA is seeking plant varieties that could grow best in space, providing food for astronauts to eat on their way to future deep space destinations, including Mars. Teachers and students in South Florida recently began experiments to test a wide spectrum of seeds to see which would flourish in different conditions.

“Once you tell the students that the plants are candidates for space and for astronauts to eat on their journey to Mars they start paying a lot of attention,” said Trent Smith, project manager for Veggie, a plant-growth system researching ways to grow edible plants in orbit. “These answers are not in the back of the book. Whatever they find when they grow their plants, they are finding it out for the first time for anyone. They are a whole corps of citizen-scientists.”

The project began its second year in early September when teachers from 115 schools in and around Miami met at Fairchild Tropical Botanic Garden in Coral Gables, Florida, to receive growing stations similar to the ones astronauts and scientists use for space research. The containers use LED lights in shades of red, blue, and this year white, along with a fertilizer mix that approximates what seeds would find in orbit.

The students and teachers are planting different varieties to see how they grow. The plants grown were chosen in part by how little is known about them. In other words, the students will perform research that will help show NASA scientists which plants are good candidates to try to grow in space.

“It’s very powerful to put the science in the hands of the students,” said Amy Padolf, director of education at Fairchild. “It is putting what they have learned to use in a very practical way.”

The more participation, the more seed varieties researchers can either mark down for space travel consideration or cross off the list. It’s an enormous help for plant scientists, Smith said.

“We don’t have time to check out every leafy green, every plant, we just don’t,” Smith said. “There are thousands of plant varieties and we can’t check all of them ourselves, so that’s where these students are giving us a lot of help.”



NASA's Gioia Massa and Trent Smith kick off Fairchild Challenge at Fairchild Tropical Botanic Garden in South Florida. Photo courtesy of Fairchild Tropical Botanic Garden

Two years into the partnership, the schools have tested dozens of edible, leafy plants. The classrooms upload data to Fairchild Tropical Botanic Garden where the Fairchild and NASA team review results. They also are required to post weekly social media photos tracking the progress of their plants. This year the tweets can be found on Twitter at, “@GrowBeyondEarth”, or they can be viewed at <https://twitter.com/GrowBeyondEarth?lang=en>.

“Measuring key parameters is what honest-to-God scientists do,” Smith said. “It’s not real glamorous, it’s collecting a lot of real data.”

Gioia Massa, NASA payload scientist for Veggie and the rest of the science team have been working to answer questions about growing plants in space for several years during their research at Kennedy Space Center. The work paid off dramatically during several recent missions as astronauts grew red romaine lettuce plants and zinnia flowers in orbit aboard the International Space Station. Veggie is sponsored by NASA’s Space Life and Physical Sciences Research and Applications.

The astronauts even sampled the fresh flavors of some of the lettuce. NASA hopes astronauts on deep-space exploration missions such as those to Mars can take along seed packs to grow a portion of their food during the voyages. The goal is not to provide a major food source, but rather to enhance astronaut diets with fresh vegetables and provide a sense of their home planet. There also are positive psychological benefits to astronauts growing plants in orbit, especially on the way to Mars when the size of the Earth shrinks by the week.

The plant studies also look at different harvesting techniques for plants, including cut-and-come-again, when some of the leaves are removed, but others left on. Harvesting a little at a time and keeping the plant intact is expected to enable astronauts to enjoy more fresh food in space in comparison to simply harvesting the whole plant when mature.

The partnership developed soon after the Fairchild Tropical Botanic Garden learned about the Veggie project and the Veggie



**“We don’t have time to check out every leafy green, every plant, we just don’t,” Smith said. “There are thousands of plant varieties and we can’t check all of them ourselves, so that’s where these students are giving us a lot of help.”**

– Trent Smith  
Project Manager for Veggie

Zinnia flowers in the Veggie ground control system base at Kenney Space Center are being prepared for harvest inside a controlled environment chamber that mimics the LED lights in the Veggie growth system on the International Space Station. Photo credit: NASA/Bill White

team learned about a Fairchild project. NASA awarded Fairchild a grant to help with its education effort.

One of Fairchild’s hallmark STEM outreach activities is its Million Orchid Project, which enables students to develop new methods to grow and transplant South Florida native orchids in hopes of restoring the orchid population. Smith and Massa realized the STEM Million Orchid Project and its power to engage and enable students to perform real science experiments could be used to assess space crop candidates, because orchids are tough to grow and make flourish. There was a real engine to bring science experiments to the students and the students to test and provide real data for crop assessment.

“There was a real mutual respect and excitement for what each other was doing,” Smith said.

Smith and Massa acted as the judges for the first year of the project, grading each of the 115 schools’ results.

Although the most obvious difference between space and Earth farming is the presence of gravity, Smith said the Veggie experiments have shown that plants depend on many other factors to grow well. Plants that are robust on Earth and grow in a wide variety of conditions likely will have a good chance of growing in orbit.

“If you get a plant that can grow well in all the classrooms — some are hot, some are really cold, kids are sneezing on them, the humidity is always changing — that’s a plant worth looking at for growing in space,” Smith said.

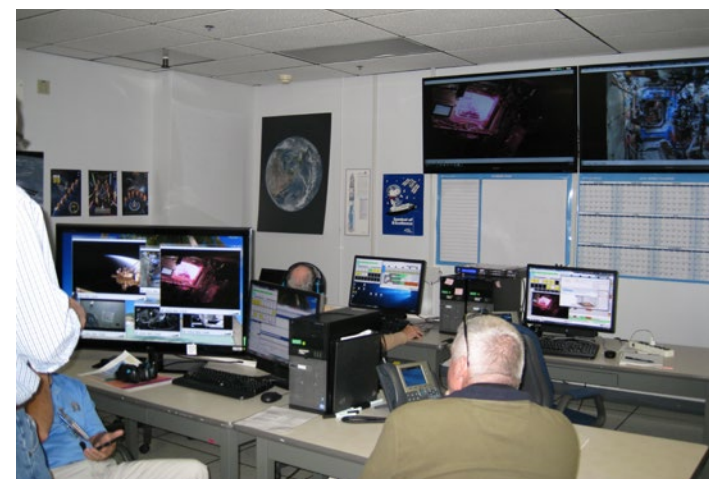
# VEG-03

## Third lettuce crop begins growing aboard station

BY ANNA HEINEY

Just as farmers on Earth are planting leafy greens for the fall growing season, astronauts aboard the International Space Station are planting their third in-orbit crop of red romaine lettuce.

Early this morning, NASA astronaut Shane Kimbrough initiated the Veg-03 experiment, one of his first science assignments as a new crew member aboard the orbiting laboratory. As Kimbrough worked, members of the Veggie team watched from their consoles in the Experiment Monitoring Area located in the Space Station Processing Facility at NASA's Kennedy Space Center. A live video downlink from the orbiting laboratory allowed the scientists to remotely watch Kimbrough's actions and ensure he did not encounter any challenges with the activity or hardware.



Veggie team members monitor Veg-03 activation aboard the International Space Station via a live video downlink to the Experiment Monitoring Area in the Space Station Processing Facility at NASA's Kennedy Space Center. Photo credit: NASA

"Operations went great today! A little slower than expected, but all plant pillows were successfully primed for the first time in our Veg series," said Nicole Dufour, NASA's Veggie project manager. Plant pillows are small pouches already containing a growth medium, fertilizer and seeds; to start them growing, astronauts simply add a little water.

"We previously have had some hardware issues that prevented at least one pillow from each 'grow out' from being successfully primed, so we were very excited to achieve that milestone," she added.

Astronauts on future long-duration space missions will need to be able to grow their own food to supplement their diets. Using the Veggie plant growth facility aboard the station, Veg-03 builds on the successes of previous studies, including Veg-01, which resulted in the first-ever on-orbit harvest and sampling of fresh produce during the summer of 2015. Techniques learned from Veggie crops will sow benefits on Earth and help NASA prepare for the Journey to Mars.

***"We expect this will increase the on-orbit crop yield, as well as allow for more opportunities to supplement our astronauts' diets with fresh, nutritious food from the same plants, which is an important goal of the 'pick-and-eat' food concept."***

– Nicole Dufour  
NASA's Veggie Project Manager

The Veg-03 crop will be the Veggie team's first in-orbit attempt at a new, repetitive harvest technique termed 'Cut-and-Come-Again'.

"Once the plants are approximately four weeks old, a selection of leaves can be harvested for a bit of fresh lettuce and possibly science samples. Meanwhile, some leaves are left intact along with the core of the plant, and will continue to grow and produce more leaves," Dufour explained.

"We expect this will increase the on-orbit crop yield, as well as allow for more opportunities to supplement our astronauts' diets with fresh, nutritious food from the same plants, which is an important goal of the 'pick-and-eat' food concept."

Dufour reports the team is anxiously awaiting germination results, expected early next week.

[Learn more about Veggie at http://go.nasa.gov/2eKnPro.](http://go.nasa.gov/2eKnPro)

[Learn more about Veg-03 at http://go.nasa.gov/1VCrcnc.](http://go.nasa.gov/1VCrcnc)

# LEED CERTIFIED

## Sustainable, efficient data center takes the silver

BY ANNA HEINEY



The Kennedy Data Center opened in October 2015. By consolidating multiple data centers into a single new one, Kennedy streamlined IT operations and improved efficiency. Photo credit: NASA

When officials at Kennedy Space Center began planning for a modern data center, they decided from the very beginning they wanted the new facility to meet stringent standards for sustainability and environmental performance.

On Aug. 29, those extra efforts paid off when the Kennedy Data Center (KDC) was awarded LEED Silver Certification by the U.S. Green Building Council.

"This achievement was very important to Kennedy Space Center and especially to the KDC team after more than three years of planning, design and construction to bring the facility all the way up to fully operational," said NASA's David Sumner, who served as the data center's facility project manager throughout its design and construction.

LEED stands for Leadership in Energy and Environmental Design. It's a widely used rating system through which buildings, campuses and even entire communities can be ranked according to factors such as sustainability, water and energy efficiency, greenhouse gas emissions and many more. The four available rating levels are Certified, Silver, Gold and Platinum.

"We strive in all new and renovated facilities to achieve at least a LEED Silver rating," Sumner explained.

Opened in October 2015, the Kennedy Data Center is a key element in the spaceport's IT infrastructure. Within its 16,000 square feet, it consolidates computing and data handling capability that previously required five separate data centers totaling about 45,000 square feet. The new facility was built to increase reliability while reducing square footage, energy costs, and operations and maintenance costs.

Ensuring the new data center would meet the requirements for LEED Silver certification wasn't easy.

"The data center has a very specific purpose, with high power consumption and low personnel usage per square foot of facility, especially compared to a standard office building – and this made LEED certification more challenging to achieve," Sumner explained.

The team succeeded by starting early. Regional materials and recycled content were used whenever possible. The finished data center boasts optimized energy performance, reduction in water use through low-flow plumbing fixtures and natural irrigation, a sustainable site design, and other innovations, such as "green" housekeeping and pest management.

The team also enlisted the help of LEED-accredited sustainability consultant EXP, which developed, submitted, coordinated and completed the LEED certification documentation required by the U.S. Green Building Council.

The Kennedy Data Center is part of the first phase of the Central Campus currently in development in the heart of the spaceport's Industrial Area. A new seven-story, 200,000-square-foot headquarters building, already under construction, will anchor the Central Campus and provide office space for about 500 employees. Like the data center, it is designed with sustainability and efficiency in mind.

"After the excitement of completing the KDC construction and having it prove operational, receiving the LEED silver certification was very rewarding," Sumner said. "It further proves our team built a highly technical, special-operations facility while still maintaining sustainable environmental protection and energy reduction."

### Central Campus Update

A large crane towers overhead as the new, seven-story headquarters building takes shape in the industrial area at Kennedy Space Center. The 200,000-square-foot facility will anchor the spaceport's Central Campus and house about 500 NASA civil service and contractor employees. The building will be more energy efficient than the current Headquarters building and will feature the latest in office and administrative building technology to fulfill Kennedy's role as the premiere multi-user spaceport for NASA and, increasingly, commercial entities. Photo credit: NASA/ Kim Shiflett





# PERU LOOKING UP

## NASA Manager advises Peruvians: collaboration is key

BY BOB GRANATH

NASA was born in 1958 when the Space Age was just getting underway. In the decades to follow, the agency has collaborated with nations around the world to share the benefits of space flight and exploration. The agency now is working with experts in South America to help them expand their opportunities.

In early August, Jeffrey Thon, Landing and Recovery Subsystem manager for the Commercial Crew Program (CCP) at NASA's Kennedy Space Center, spoke to university students and young professionals attending the Second South American Space Generation Workshop in Lima, Peru. NASA is helping the Peruvians define a path toward becoming part of a vibrant South American space program.

"Peru is an emerging economy," said Thon, whose organization is in Kennedy's Engineering Directorate. "As a nation, they now are advancing their own technologies. As a result, many Peruvians are looking to expand their opportunities, including reaching into space."

During the early 13th century, the Inca civilization originated in the nation's highlands. Their astronomers developed calendars based on movements of the sun and phases of the moon.

The people of Peru again are looking to the heavens.

Peru formed its space agency, the Comisión Nacional de Investigación y Desarrollo Aeroespacial (National Commission for Aerospace Research and Development) or CONIDA, in 1974.

"Those attending the South American Regional Space Generation Workshop were mainly young professionals between 25 and 35 years," Thon said. "They are hoping to foster collaboration between CONIDA, industry and academia to build a robust space program for Peru. They also want to find ways to work with NASA and join efforts led by ESA at their launch site in Kourou."

ESA is the European Space Agency. Along with the French space agency, CNES (National Centre for Space Studies), ESA and commercial companies established the Guiana Space Centre in Kourou, French Guiana, in 1968.

"The workshop included presentations and discussions on how Peruvians can develop and build on their emerging capabilities," said Thon. "Students and professors at several universities have already taken advantage of opportunities to fly CubeSats and



The European Space Agency's fifth and final Automated Transfer Vehicle (ATV) cargo carrier lifts off atop an Ariane 5 rocket from Kourou, French Guiana, on July 29 2014. The ATV-5 is headed to the International Space Station, loaded with food, scientific experiments and other supplies. The Guiana Space Centre was established in South America in 1968. Photo credit: European Space Agency

nanosatellites as part of American-launched spacecraft."

NASA's CubeSat and Educational Launch of Nanosatellites initiatives provide opportunities for small satellite payloads to fly on rockets planned for upcoming missions. Both originally were created to attract students to further studies in the disciplines of science, technology, engineering and mathematics, or STEM.

During 2013 and 2014, Pontificia Universidad Católica del Perú (Pontifical Catholic University of Peru), Universidad Alas Peruanas (Alas Peruanas University), and Universidad Nacional de Ingeniería (National University of Engineering), all located in the nation's capital of Lima, built cubesats that were launched on NASA rockets.



In early August, Jeffrey Thon, Landing and Recovery Subsystem manager for the Commercial Crew Program (CCP) at Kennedy Space Center, spoke to university students and young professionals attending the Second South American Space Generation Workshop in Lima, Peru. It was part of NASA's efforts to help the Peruvians define a path toward becoming part of a vibrant South American space program. Photo courtesy of Mars Society Peru/Mónica Abarca

"These satellites, while small, are helping Peruvian students develop the capability to launch and track objects in space," Thon said. "This creates a framework to help their efforts grow and attract interest and funding from high-tech industries."

Collaboration was the focus of Thon's presentation to the group. "I explained how NASA now is relying on industry partners to develop the spacecraft to take our astronauts to low-Earth orbit," he said. "That's the core of our Commercial Crew Program, relying on companies such as Boeing and SpaceX to provide transportation to the International Space Station while the agency focuses on developing the new technologies needed to explore deep space."

According to Thon, differing viewpoints can be advantageous. "When the United States partners with different nations, we don't want them to change to do everything our way," he said.

"There are many advantages in diversity. We want our partners to not only bring their expertise, but bring their culture, their viewpoint, their different approach. This gives us the benefits of new ideas as we go forward."

As NASA continues development of the Orion spacecraft and Space Launch System rocket, Thon believes expanding international partnerships will be a key to success.

"The journey to Mars is a complex, expensive endeavor," he said. "It will be crucial to involve not only the nations such as those currently involved in the space station program, but Peru and other countries in South America and around the world."

With a population estimated at 31.2 million, modern Peru is the third largest country in South America, following Brazil and Argentina.



# DEEP BREATH



The Advanced Cryogenic Breathing Apparatus (ACryoBA) is a liquid air-based, self-contained breathing apparatus (SCBA). It has one- and two-hour versions. Photo credit: NASA/Dimitri Gerondidakis

## Kennedy hopes to share advanced cryogenic breathing apparatus technology

BY FRANK OCHOA-GONZALES

**B**ecause of NASA's unique mission requirements, a new breathing apparatus concept has emerged to help with hazardous ground operations and rescue situations.

NASA and the Office of Mine Safety and Health Research (OMSHR) have been trying to resolve current technological issues with cryogenic life support so that it can be successfully commercialized, and develop new applications for cryogenic technologies in life support targeting current issues in the mining life-support industry.

Kennedy Space Center has been using liquid air packs for many years for astronaut rescue missions, but the technology has not been used outside of NASA missions.

"Our equipment here doesn't have to meet all that criteria to be certified; therefore, no one else in the outside world has used it," said David Bush of Kennedy's Biomedical Engineering and Research Laboratory. "There are several limitations that prevent anyone else using that technology. For anyone else in the industry to use cryogenic life-support technology, they have to be certified."

In 2006, OMSHR was directed by the MINER Act of 2006

to explore mine safety improvements. In coordination with the National Institute for Occupational Safety and Health (NIOSH), a project born under an Interagency/Space Act Agreement in 2012, became a reality.

The use of liquid air to save lives of miners in the event of an emergency could be shared.

Using liquid air has many advantages. It has a greater duration for volume, allows for different cooling options and requires much lower pressure. These factors are huge when a miner is trapped in a small space. It's liquid air-based, so it vaporizes the liquid air and that's what the user breathes.

One of the problems? Development of a quantity sensor in a liquid system was a challenge due to cryogenic temperatures and a moving liquid level in wearable systems. Bush and other engineers currently are working on two solutions.

The first is a two-point system based on thermocouples. This would show when the tank is full and a quarter full. But the system works only between +/- 70 degrees of vertical and thus incorporates an accelerometer to ensure it is within range. It currently is being

integrated into existing Advanced Cryogenic Breathing Apparatus (ACryoBA) prototypes and tested. There also is a plan to develop a much smaller version with mask integrated LED.

The second is an external sensor array with a float in the Dewar full-range all orientation system which allows for zero to 100 percent indications in any orientation. It currently is undergoing proof of concept testing.

Other issues included the overall attitude independence which eventually was solved with an Attitude Independent Pickup, and the quick fill, solved with an automatic fill/use quick disconnect.

**"Our equipment here doesn't have to meet all that criteria to be certified; therefore, no one else in the outside world has used it."**

- David Bush  
Engineer at Kennedy Space Center's  
Biomedical Engineering and Research  
Laboratory



The Cryogenic Air Storage and Fill Station (CryoASFS) is a zero-loss liquid-air storage station capable of rapidly refilling cryogenic air packs. Photo credit: NASA/Dimitri Gerondidakis



The NIOSH project has five subprojects in an effort to improve technology and make liquid air life support a viable commercial alternative to traditional compressed gas solutions. There currently are three NIOSH subprojects and related work on small scale liquid air production. They include:

- **Cryogenic Breathing Apparatus (CryoBA)**  
– *Liquid air-based SCBA*
- **Cryogenic Air Storage and Fill Station (CryoASFS)**  
– *Long term storage of liquid air with rapid filling capabilities*
- **Advanced Cryogenic Breathing Apparatus (ACryoBA)**  
– *A project to improve on the design of the initial CryoBA*

These subprojects specifically target emergency mine egress, but have potential application in Search and Rescue (SAR), Hazmat, Fire, Department of Defense (DOD), and more.

Prior to the project, Kennedy has used cryogenics life-support technology for many years for ground operations. Personally used liquid air packs, which are cryogenic self-contained breathing apparatuses, or SCBAs, have been used at Kennedy for crew rescue for many years. Kennedy also uses the SCAPE suit, which has a cryogenic air-pack version, a two-hour air pack to drive the suit.

David Bush dons the Advanced Cryogenic Breathing Apparatus (ACryoBA).  
Photo credit: NASA/Dimitri Gerondidakis

# PROJECT GEMINI

PART 9



During his first stand-up spacewalk on Nov. 12, 1966, Buzz Aldrin photographed landmarks on Earth. While doing so, he set his camera on the edge of the hatch, pointing it in his direction. He then took what he now describes as "the first space selfie." Photo credit: NASA/Buzz Aldrin

## Gemini XII crew masters the challenges of spacewalks

BY BOB GRANATH

In the 20 months following the first piloted Gemini mission, NASA astronauts demonstrated the ability to change orbits, perform rendezvous and docking, along with spending up to two weeks in space. Spacewalking, on the other hand, remained an enigma. With only one more Gemini flight on the schedule, solving the problems of working outside a spacecraft would be the primary goal for Gemini XII.

As was the case on the previous four missions, the Gemini XII flight plan called for rendezvous and docking with a target vehicle. But, according to Dr. George Mueller, NASA's associate administrator for Manned Spaceflight, mastering what NASA called an extravehicular activity (EVA) or spacewalk would be crucial in proving the agency was ready to move ahead with Apollo and achieving the goal of landing a man on the moon before the end of the decade.



Gemini XII pilot Buzz Aldrin, left, and command pilot Jim Lovell stand in a Gemini mockup during training at NASA's Manned Spacecraft Center (now Johnson Space Center) in Houston. Photo credit: NASA

“I feel that we must devote the last EVA period in the Gemini Program to a basic investigation of EVA fundamentals,” he said.

To take on the challenges of this crucial flight, NASA assigned a veteran of the longest spaceflight to date and the astronaut who helped “write the book” on orbital rendezvous.

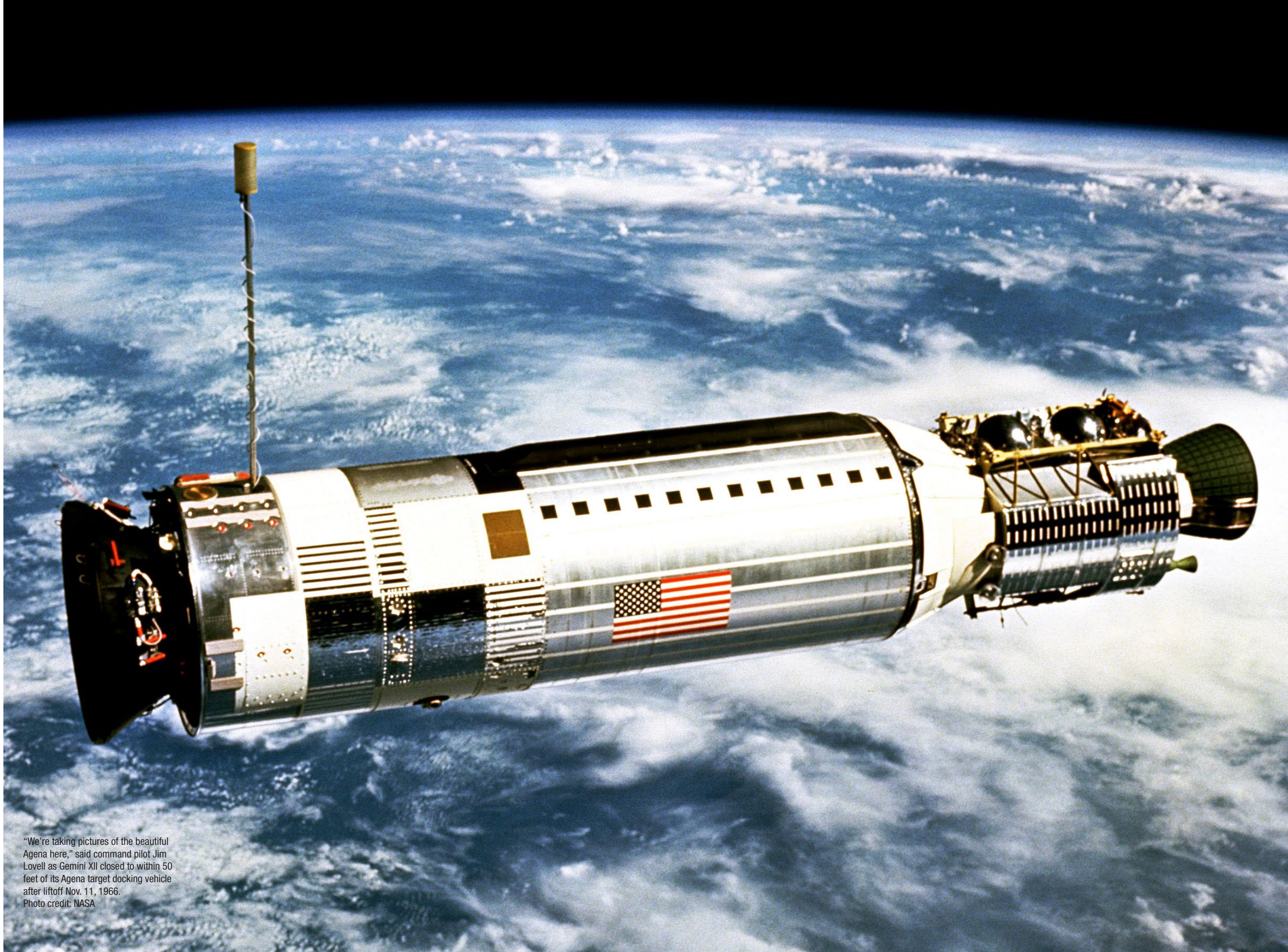
The command pilot was Jim Lovell who served on the 14-day Gemini VII mission in December 1965. A Naval aviator, he went on to be a member of the Apollo 8 crew, the first mission to orbit astronauts around the moon in 1968. As commander of Apollo 13 in 1970, Lovell became the first person to travel in space four times.

Flying with Lovell was U.S. Air Force pilot, Buzz Aldrin, the first astronaut to have earned a doctorate. In 1963, he was awarded a doctorate in astronautics from the Massachusetts Institute of Technology. His graduate thesis was “Line-of-sight guidance techniques for manned orbital rendezvous.” Aldrin went on to serve as lunar module pilot on Apollo 11 in 1969, during which he and Neil Armstrong become the first humans to walk on the moon.

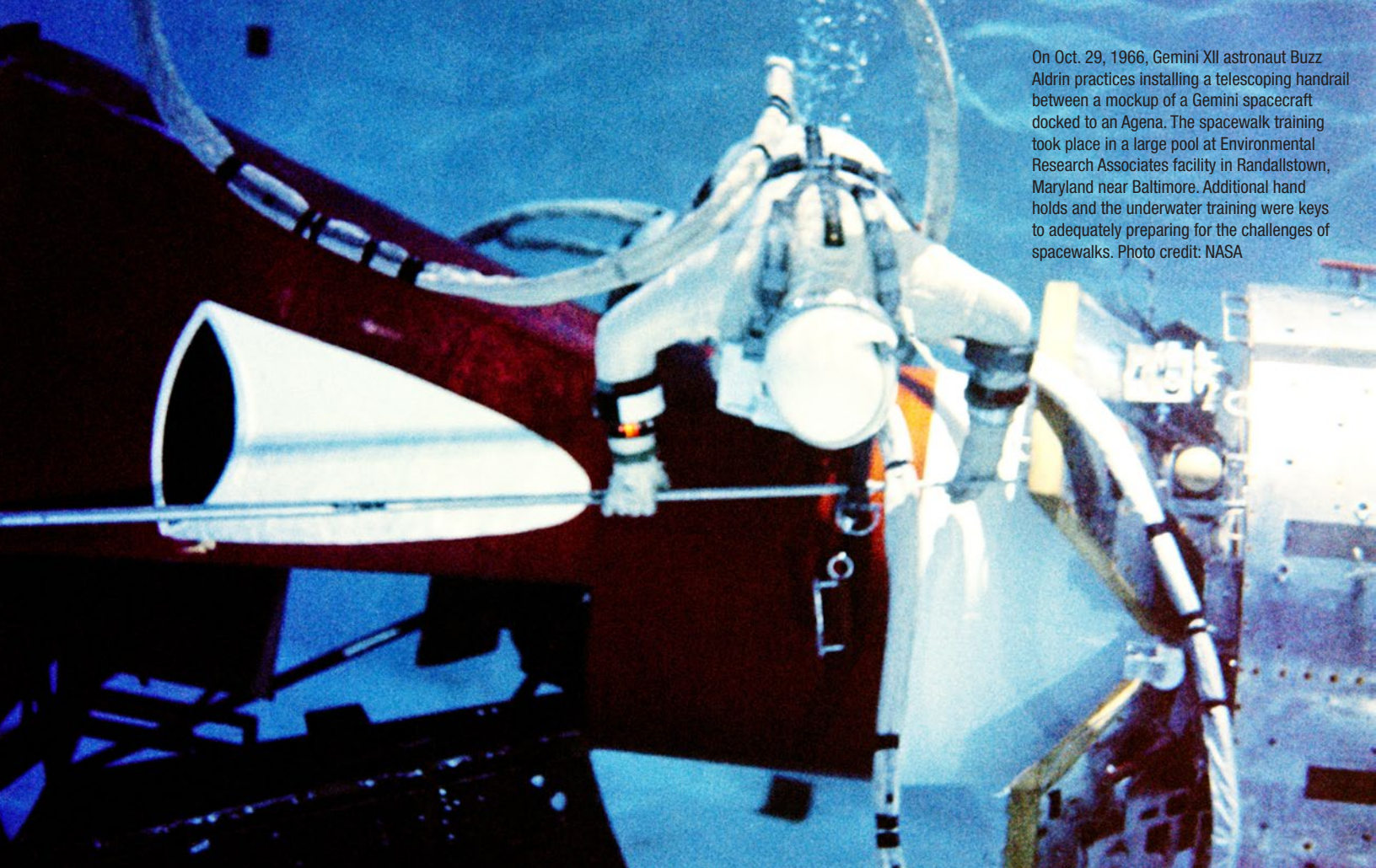
To make lunar EVAs possible, spacewalking during Gemini flights was a crucial learning experience in Gemini. Ed White’s spacewalk on Gemini IV made it look easy. But the experiences of Gene Cernan, Mike Collins and Dick Gordon on three later missions demonstrated a new approach was needed for both training and performing spacewalks.

Through Gemini XI, EVA training focused on use of the KC-135 aircraft flying parabolas. During the dives, astronauts experienced up to 30 seconds of weightlessness. But this was followed by the aircraft climbing and the astronauts having a period of rest. Consequently, spacewalkers in training were not facing the types of continued strenuous work and fatigue experienced by Cernan, Collins and Gordon.

Dr. Robert Gilruth, director of the Manned Spacecraft Center (now Johnson Space Center) in Houston, ordered a new approach.



“We’re taking pictures of the beautiful Agena here,” said command pilot Jim Lovell as Gemini XII closed to within 50 feet of its Agena target docking vehicle after liftoff Nov. 11, 1966.  
Photo credit: NASA



On Oct. 29, 1966, Gemini XII astronaut Buzz Aldrin practices installing a telescoping handrail between a mockup of a Gemini spacecraft docked to an Agena. The spacewalk training took place in a large pool at Environmental Research Associates facility in Randallstown, Maryland near Baltimore. Additional hand holds and the underwater training were keys to adequately preparing for the challenges of spacewalks. Photo credit: NASA

“I have given a great deal of thought recently to the subject of how best to simulate and train for extravehicular activities,” Gilruth said in a memo to Deke Slayton, director of Flight Crew Operations. “Both zero ‘g’ trajectories in the KC-135 and underwater simulations should have a definite place in our training programs.”

The alternate approach uses a large pool of water for “neutral buoyancy.” In this method, special weights are added to the astronaut’s spacesuit creating buoyancy to offset gravity so the astronaut neither rises nor sinks.

Aldrin spent several sessions of more than two hours each working with a Gemini mockup in the pool at the Environmental Research Associates facility near Baltimore, Maryland.

This approach became so successful, underwater training has become the primary spacewalk training method used by the United States, Russia and China. Today, NASA’s Neutral Buoyancy Laboratory in Houston is large enough to include mockups of major sections of the International Space Station. As such, it is one of the largest indoor bodies of water in the world, with 6.2 million gallons of water.

With the additional training behind them, Lovell and Aldrin lifted off aboard their Gemini XII spacecraft atop a Titan II rocket on Nov. 11, 1966. They followed one hour, 39 minutes after their Agena was placed in orbit by an Atlas launch vehicle.

The first order of business was rendezvous with the Agena. Things were going well when Lovell confirmed they spotted their

target 98 miles away. But minutes later there was trouble.

“We seem to have lost our radar lock-on at about 74 miles,” Aldrin said. “We don’t seem to be able to get anything through the computer.”

Aldrin pulled out a sextant and his slide rule and put his MIT doctoral research to work. With the sextant, Aldrin measured the angle between the horizon and the Agena. Aldrin confirmed the information with his rendezvous chart, then calculated corrections with the spacecraft’s computer.

“How are you doing up there?” asked fellow astronaut Pete Conrad during the third orbit. He was serving as capsule communicator, known as capcom, in Mission Control.

“We’re taking pictures of the beautiful Agena here,” Lovell said as Gemini XII closed in on its target.

“We’re giving you a GO for docking,” Conrad said.

“We are docked,” Lovell reported four minutes later as the combined spacecraft orbited south of Japan in range of the tracking ship Coastal Sentry Quebec.

During flight day two, Aldrin began practicing some of the new processes for spacewalks. This would be a two-hour, 18 minute EVA limited to standing in the hatch to familiarize himself with the environment, as well as conducting Earth and ultraviolet astronomical photography.

“The hatch is coming open,” he said. “Man, look at that.”

Aldrin expressed amazement seeing so much of Earth and the universe once outside the confines of the spacecraft.

One of his first jobs was to install a handrail between his hatch and the docking collar of the Agena. This would aid his movements during a full spacewalk the next day. As Aldrin took pictures of landmarks on Earth, he offered the usual photographer’s “suggestion.”

“Okay, tell everybody down there to smile,” he said to capcom Conrad.

Having set up a camera on the edge of his hatch, Aldrin pointed the camera in his direction.

“Now let me raise my visor and I’ll smile,” he said taking what Aldrin now describes as “the first space selfie.”

With the space stand-up EVA completed, the next day came the crucial test of a new approach to spacewalking.

“I’m free now and the only thing that’s holding me is the one hand on the handrail,” Aldrin said as he used the aid he installed the day before.

In addition to revised preflight training techniques, more handrails and handholds were added along with a waist tether giving the spacewalker the ability to turn wrenches and retrieve experiment packages without undue effort.

Aldrin’s approach was to go about his work slowly and deliberately. He would work for a while then rest, even if a reminder was needed.

“Now do you know what you’re going to do?” Lovell asked.

“Go ahead, clue me in,” Aldrin said.

“You’ll get a rest for two minutes,” Lovell said.

Aldrin then attached a tether from the Agena for the gravity-gradient experiment. With the handholds, he did not experience the problems Gordon encountered on the previous flight.

Next, Aldrin moved to the spacecraft’s aft adapter where he placed his feet in overshoe restraints and attached waist tethers. With these supports in place, he was able to fasten rings and hooks, connect and disconnect electrical and fluid connections, tighten bolts and cut cables.

“I’ve got the cutters,” Aldrin said. “They’re cutting the strap seam quite nicely.”

Aldrin again went forward to a box attached to the Agena. Lovell photographed him as he pulled electrical connectors apart and put them together again, then tried out a torque wrench designed for the Apollo program.



Buzz Aldrin installs a handrail between the Gemini and Agena spacecraft during his first stand-up spacewalk. This was something he had practiced in underwater training. Gemini XII is docked to the Agena target docking vehicle in background. Photo credit: NASA



Following the Gemini XII splashdown Nov. 15, 1966, astronauts Buzz Aldrin, left, and Jim Lovell are welcomed aboard the recovery aircraft carrier, USS Wasp, concluding their four-day mission. Photo credit: NASA

With all his work successfully completed and with no fatigue, Aldrin returned to his Gemini seat after two hours, nine minutes outside.

The riddle of spacewalking was solved.

The next task for Gemini XII was to undock from the Agena and maneuver their craft to keep taut the tether attached by Aldrin during his spacewalk. By firing their thrusters to slowly rotate the combined spacecraft, they, like Gemini XI, were able to use centrifugal force to generate a small amount of gravity during the four hour, 20 minute exercise.

Aldrin's third time outside Gemini XII and his second stand-up on the seat spacewalk, was on the fourth flight day. He took numerous ultraviolet photographs of stars and constellations during one hour, 11 minutes outside.

After the mission, NASA's "Summary of Gemini Extravehicular Activity" noted that Gemini XII's spacewalks demonstrated all the tasks attempted were feasible when body restraints were used to maintain position. But, "the most significant result was that underwater simulation duplicated the actual extravehicular actions and reactions with a high degree of fidelity."

Another repeat of a test on Gemini XI was a computer controlled re-entry on Nov. 15, 1966.

"Gemini XII, Houston," capcom Conrad said. "Our data shows you right on the money."

In fact, Lovell and Aldrin splashed down just three miles from their target, near the recovery aircraft carrier USS Wasp sailing 600

miles east of Cape Kennedy.

The next day, Lovell and Aldrin were flown from the USS Wasp to the Cape's skid strip where they were welcomed by Kennedy's center director, Dr. Kurt Debus.

"We feel everyone here did an outstanding job in getting us into space," Lovell said to those in attendance. "It takes a lot of people to fulfill a program. It's the untiring efforts of thousands who got us up to there and back."

Gemini Program Manager Walt Williams looked ahead to Apollo.

"It is now time to go on," he said. "We will be able to go on with confidence because there was this program and it was called Gemini."

President Lyndon B. Johnson also had high praise for those who made the Gemini Program possible.

"Today's flight was the culmination of a great team effort, stretching back to 1961," he said. "It directly involved more than 25,000 people in the National Aeronautics and Space Administration, the Department of Defense, other government agencies, universities, other research centers and in American industry."

The President then looked forward to Apollo.

"The months ahead will not be easy, as we reach toward the moon," he said, "but with Gemini as the forerunner, I am confident that we will overcome the difficulties and achieve another success."



*"It is now time to go on. We will be able to go on with confidence because there was this program and it was called Gemini."*

– Walt Williams  
Gemini Program  
Manager

At Cape Kennedy (now Cape Canaveral) Air Force Station, the crew for Gemini XII arrive at Launch Complex 19. Command pilot Jim Lovell is followed by pilot Buzz Aldrin. The signs on their backs note that this mission is the final flight of the Gemini Program. Photo Credit: NASA

EDITOR'S NOTE: This is the final article in a series of features marking the 50th anniversary of Project Gemini. The program was designed as a steppingstone toward landing on the moon. The investment also provided technology now used in NASA's work aboard the International Space Station and planning for the Journey to Mars. For more, see "On the Shoulders of Titans: A History of Project Gemini." If you missed any of the features in this series, click on any of the links below.

- [Gemini III: Gemini Pioneered the Technology Driving Today's Exploration](#)
- [Gemini IV: Learning to Walk in Space](#)
- [Gemini V: Paving the Way for Long Duration Spaceflight](#)
- [Gemini VII & Gemini IV: Dual Gemini Flights Achieved Crucial Spaceflight Milestones](#)
- [Gemini VIII: Gemini's First Docking Turns to Wild Ride in Orbit](#)
- [Gemini IX Crew Found 'Angry Alligator' in Earth Orbit](#)
- [Gemini X Sets Records for Rendezvous, Altitude Above Earth](#)
- [Gemini XI: Demanding Mission Flies on Top of the World](#)
- [Gemini XII Crew Masters the Challenges of Spacewalks](#)



Hurricane Matthew is seen in this photograph taken by Expedition 49 Flight Engineer Kate Rubins on Oct. 4 as it hit the Caribbean Sea and made its way towards Florida. Check out some photos of the damaged cause by Hurricane Matthew inside this issue. Photo credit: NASA

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