



KENNEDY SPACE CENTER'S

# SPACEPORT

m a g a z i n e



# GEARING UP



**One-Year Mission sheds light on human challenges  
in deep space as Kennedy preps Orion to get us there**



# KENNEDY SPACE CENTER'S SPACEPORT MAGAZINE CONTENTS

- 4.....Kennedy's input to the One-Year Mission
- 11.....Orion crew module processing begins
- 16.....Zinnias set stage for deep-space food crop research
- 20.....More Florida launches on the way
- 25.....Engineer ensures smooth commercial crew touch down
- 30.....Commercial Crew astronaut shares her insight
- 33.....Traveling exhibit touches hearts of Kennedy workers
- 34.....Edgar Mitchell Followed 'The Way of the Explorer'
- 37.....Gemini's first docking turns into wild ride in orbit

Front Cover: A crane lowers the Orion crew module pressure vessel for NASA's Exploration Mission-1 (EM-1) onto a test stand called the birdcage inside the Neil Armstrong Operations and Checkout Building high bay at Kennedy Space Center. Technicians and engineers with Orion manufacturer Lockheed Martin will

begin preliminary checkout of the crew module. The crew module was transported from the Michoud Assembly Facility in New Orleans. The Orion spacecraft will launch atop NASA's Space Launch System rocket on EM-1, an uncrewed test flight, in 2018. Photo credit: NASA/Bill White

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



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## NASA'S LAUNCH SCHEDULE

**Date:** March 1, 11:27 p.m. EST  
**Mission:** Expedition 46 Undocking and Landing  
**Description:** One-Year Mission crew members NASA astronaut Scott Kelly and Russian cosmonaut Mikhail Kornienko will conclude 340 days aboard the International Space Station, returning in the Soyuz TMA-18M spacecraft along with Russian cosmonaut Sergey Volkov. Kelly and Kornienko arrived at the station March 27, 2015, and Volkov joined the crew aboard the orbiting laboratory Sept. 4, 2015. Landing is scheduled at 11:27 p.m. ET (4:27 UTC and 10:27 a.m. local time in Kazakhstan on March 2).  
<http://go.nasa.gov/1WSctSC>

**Date:** March 18, 5:26 p.m. EST  
**Mission:** Expedition 47 Launch to International Space Station  
**Description:** NASA astronaut Jeff Williams and cosmonauts Oleg Skripochka and Alexey Ovchinin of Roscosmos launch aboard the Soyuz TMA-20M spacecraft from the Baikonur Cosmodrome to the International Space Station.  
<http://go.nasa.gov/1VHuSAv>

**Date:** March 22, 11:02 p.m. EST  
**Mission:** Orbital ATK CRS-6  
**Description:** Orbital ATK's sixth contracted cargo resupply mission with NASA to the International Space Station will deliver science and research, crew supplies and vehicle hardware to the orbital laboratory and its crew.  
<http://blogs.nasa.gov/orbital/>

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

National Aeronautics and Space Administration

# I am KENNEDY SPACE CENTER

## JOHN FLYNN

I am a software engineer developing system software on the Gateways team for the launch control system, or LCS, under the Engineering Services Contract at Kennedy Space Center. The LCS will be used to launch the Space Launch System, or SLS, and the Orion capsule on future deep-space missions.

On the Gateways team, we are developing the command and telemetry systems that will be used to communicate between LCS and the different stages of the SLS rocket, the Orion capsule and Kennedy ground control systems.

I started working at KSC in July 2014 and am very grateful for the opportunity to work on such an exciting program.

I enjoy programming in my free time, specifically microprocessors for small embedded systems projects which involve a lot of low-level communication, so really one of my hobbies is what I do here, on a communication system for the largest rocket ever built and its payload.

Other than the technical reasons, I enjoy working on LCS because of the experienced engineers I continually am learning from and the interesting and complex problems we have to solve to reach our goals. Our goals as part of LCS are only a part of all the projects working together to reach NASA's and the United States' mission to explore deep space, Mars and other future destinations. It is very exciting to be part of the NASA team.





# Our Part

## Air to breathe and flowers to grow: What Kennedy provided to the One-Year Mission

BY STEVEN SICELOFF

The International Space Station served as astronaut Scott Kelly's workplace and laboratory during his yearlong mission in orbit, and Kennedy Space Center provided some of the basic necessities to make it a bit more like home.

Kelly and his cosmonaut crewmate, Mikhail Kornienko, launched from Kazakhstan last spring, but the research gear, maintenance equipment and much of the oxygen the crew breathed went to space from Florida's shores, made ready for flight by Kennedy teams. With the study of long-duration spaceflight as its goal, the mission was focused in large part on determining how a journey to Mars and other future flights into deep space would affect astronauts.

NASA sent more than 520 parts and systems to the station on cargo resupply missions by SpaceX and Orbital ATK launched from Florida during the year Kelly was in orbit — not counting the scientific and research-related experiment hardware. Included in that count were two high-pressure air tanks known as NORS, short for Nitrogen/Oxygen Recharge System. Those tanks — and the ones slated to go up on future cargo resupply flights — provide the crew with the air they breathe during their mission.

Also included are replacement parts for station systems ranging from electrical components to the plumbing to keep the sanitation network functional — a critical system for any home away from home. All the work and components are helping astronauts learn what it takes to operate equipment over a long period of time as they would have to do on deep space missions. The projects also

are showing engineers on Earth what the needs are off the Earth for devices. That expertise can be used on the Earth in new generations of machinery that has been evaluated in the demanding conditions of orbit.

"The station really couldn't survive without these parts we provide," said Steven Bigos, senior project manager at Kennedy for the space station. "We're very aware of how critical the hardware is. This isn't like working on your truck where, worst case, you end up on the side of the road. If we do something wrong, it could impact the safety of the crew. We know well the trust they put in us and in the hardware."

Aside from the mechanisms to make the station operate as a home and laboratory able to sustain astronauts and cosmonauts, Kennedy teams also added a few firsts to the orbiting laboratory, notably the first flower to be grown and bloom in NASA's on-orbit garden, Veggie. Having eaten lettuce grown in-orbit early in his stay in space, Lindgren started and Kelly oversaw a crop of zinnias that needed his care to grow and eventually blossom into a kaleidoscope of colors.

"You couldn't ask for a better gardener than Scott," said Trent Smith, project manager of Veggie at Kennedy. "That was a stroke of luck. Scott had already seen successful plant growth with Veggie, so when it came time to save the zinnias, Scott was already familiar with everything. That was an extra level of comfort that I had with Scott being up there."

Kelly's know-how paid off in February when he snipped the



Astronaut Scott Kelly aboard the International Space Station during his one-year mission. Photo credit: NASA

flowers to assemble a Valentine's Day bouquet in orbit. Although in orbit around Earth, astronauts say they like the feel plants and flowers bring to the station because it reminds them of home.

"I think we added a quality of life for them," Smith said.

Further into the future, the ability to grow plants such as lettuce, tomatoes and other crops is expected to enable deep-space crews to supplement their food supplies with fresh vegetables packed with vitamins and nutrients necessary for long-duration missions such as a journey to Mars.

Kelly's commitment to the mission is not expected to end with the astronaut's return to Earth. He will meet with the scientists covering all the experiments as well as review the equipment schedules and performance to refine needs and commitments for future long-duration missions. Just as it did for the mission, Kennedy is expected to play a large role in the exceptional performance of future flights as it works toward a journey to Mars.



One-year mission crew members Scott Kelly of NASA, left, and Mikhail Kornienko of Roscosmos celebrated their 300th consecutive day in space on Jan. 21, 2016. The pair spent a total of 340 days aboard the International Space Station as scientists seek to understand what happens to the human body while in microgravity for extreme lengths of time. Photo credit: NASA

Here are 10 things to know about Scott Kelly's #YearInSpace  
<http://go.nasa.gov/1WGox8R>



# By the Numbers

A look at what happened during Scott Kelly's #YearInSpace



## RECORD

Kelly and Kornienko hold the record for longest duration mission on the International Space Station (ISS)

## DAYS IN SPACE

340

## SPACEWALKS

Kelly conducted three spacewalks – the first in his career – to maintain and upgrade the ISS for future commercial crew spacecraft. His time outside totaled 18 hours, 20 minutes.

## VEHICLES

9 vehicles visited:  
1 SpaceX Dragon resupply ship  
1 Orbital ATK Cygnus resupply ship  
1 Japanese HTV resupply ship  
3 Russian Progress resupply ships  
3 Soyuz crew vehicles

## ORBITS OF THE EARTH

5,440

## ASTRONAUTS

10 astronauts and cosmonauts (aside from Kelly and Kornienko), representing six different nations (U.S., Russia, Japan, Denmark, Kazakhstan, England), arrived on the ISS

## EXPERIMENTS

Nearly 400 experiments were conducted on station

## MILES TRAVELED

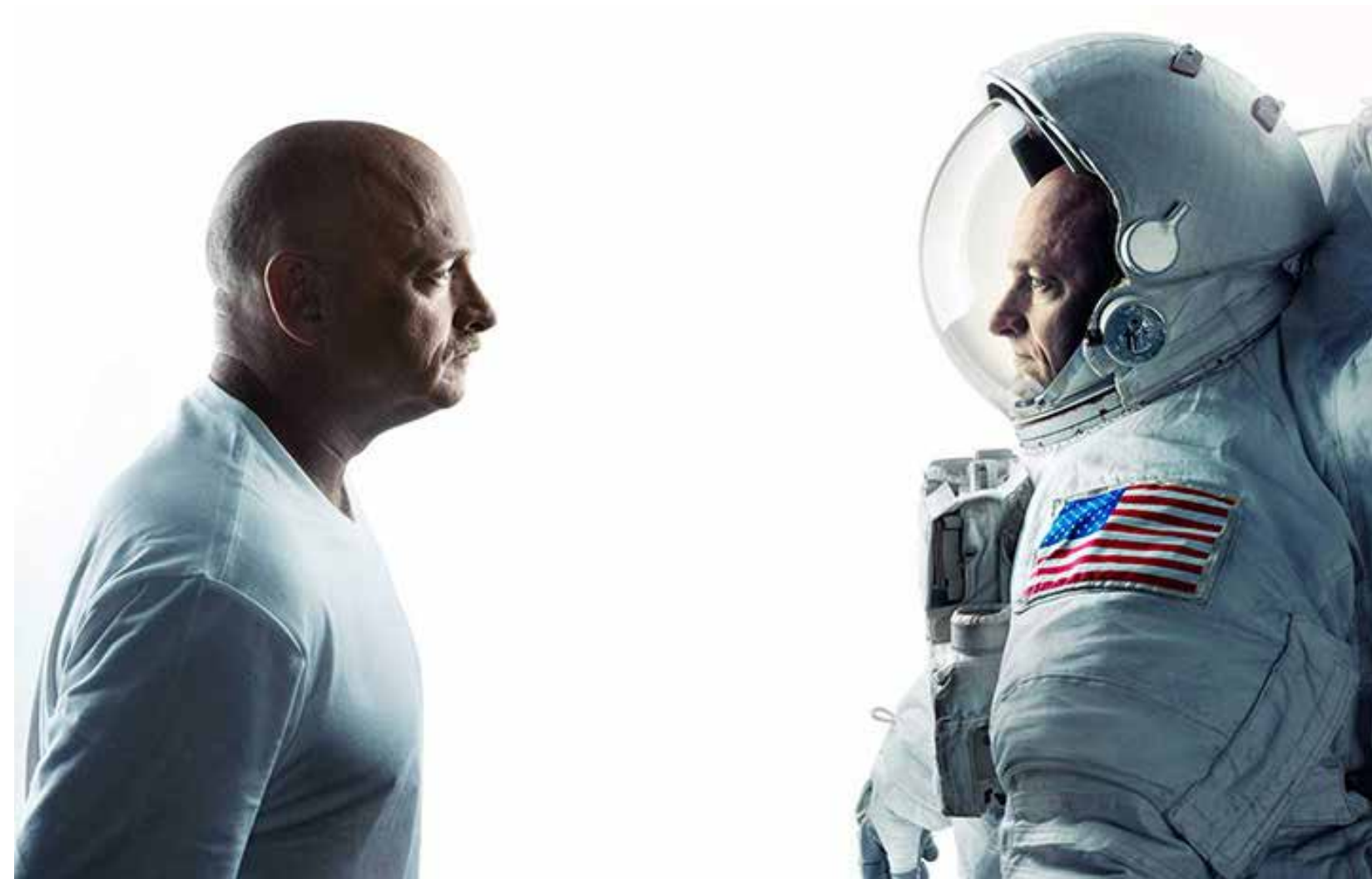
143,846,525 miles

# KELLY'S MISSION: 12 Months

# FUTURE MARS MISSION: 30 MONTHS

# Twin Studies

NASA astronaut Scott Kelly, right, and his identical twin, former astronaut Mark Kelly, are participating in a suite of investigations called the Twin Studies. The investigations focus on human physiology and behavioral health. Image credit: NASA



Learn more about the Twin Studies  
<http://www.nasa.gov/twins-study>



# Realistic Rescue

Firefighters participated in an Air Rescue Fire Fighting nighttime training exercise Feb. 17 at the Shuttle Landing Facility at NASA's Kennedy Space Center in Florida. Members of Kennedy's Fire Rescue team practiced putting out fires deliberately set on a modified aircraft fuselage.

Similar to NASA astronauts' anomaly training before a spaceflight, the team takes part in a variety of realistic drills throughout the year to be ready to respond to any emergency under any conditions.

Photo credit:  
NASA/Kim Shiflett





# JOURNEY TO MARS

## Orion crew module processing begins for first mission atop Space Launch System

BY LINDA HERRIDGE

Even though Mars is millions of miles away, the goal of sending humans there is well within reach.

The pressure vessel portion of the Orion crew module arrived at Kennedy Space Center in early February in preparation for an uncrewed trip around the moon in just two years.

Orion is a spacecraft designed to transport a crew of four to deep space. The pressure vessel is the module's underlying structure and currently is being processed while secured in a test stand called the "birdcage" inside the Neil Armstrong Operations and Checkout, or O&C, Building high bay.

"The arrival of Orion is very exciting for us," said Scott Wilson, NASA Orion production manager. "This is the first mission where the Orion

spacecraft will be integrated with the large Space Launch System rocket."

The pressure vessel arrived Feb. 1 aboard NASA's Super Guppy aircraft from the Michoud Assembly Facility in New Orleans to Kennedy's Shuttle Landing Facility, operated by Space Florida. It was offloaded and transported to the O&C the next day.

Before arriving at Kennedy, Orion spent several months at Michoud, where its seven large segments were welded together to form the pressure vessel. At Kennedy, the pressure vessel will be outfitted with additional components and then tested to ensure it is structurally sound.

During the next 18 months, more than 100,000 components will arrive at the center. A team of engineers and technicians with NASA and Orion manufacturer Lockheed Martin will integrate them with the spacecraft. Orion will be outfitted with its systems and subsystems necessary for flight. The module will receive its avionics; electrical power storage and distributions systems; thermal controls; cabin

pressure control; command and data handling; communications and tracking; guidance, navigation and control; reaction control system propulsion; and flight software and computers.

***"Orion and the Space Launch System will allow us to be leaders in space. This vehicle will go further than any of the Apollo spacecraft."***

**Mark Geyer**  
Deputy Center Director,  
Johnson Space Center

"At Kennedy, we are going to turn the pressure vessel into a fully operational spacecraft," Wilson said. "We have a robust test program that is distributed across key facilities in several states. After we complete testing here, Orion will be sent to Plum Brook Station at the agency's Glenn Research Center in Ohio for additional testing."

Wilson said there are several

months of environmental testing scheduled for the Orion spacecraft.

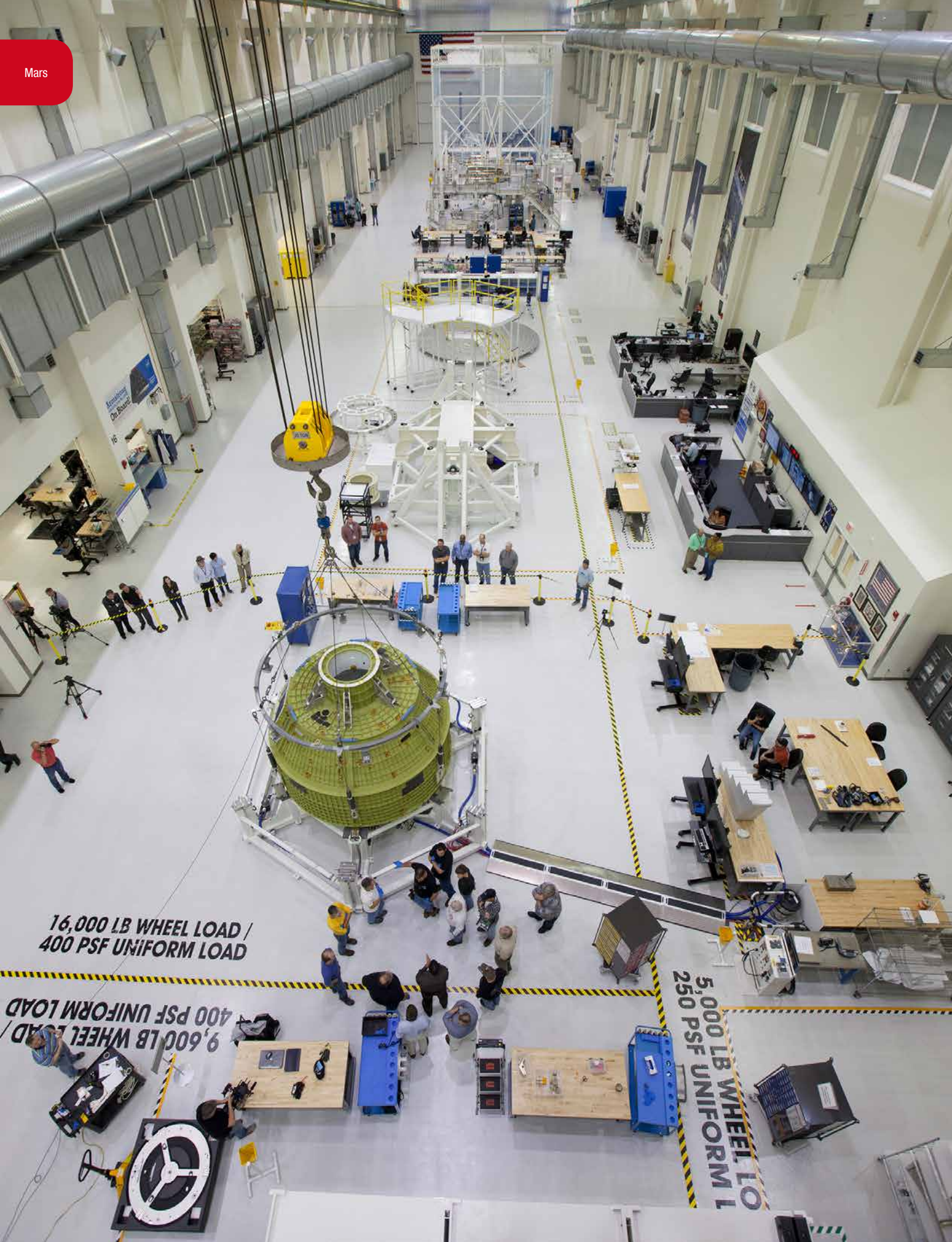
"We want to make sure the vehicle itself is good for its mission, which is called acceptance testing," Wilson said. "But, the larger set of testing is what we call qualifications. We qualify our design."

Thanks to lessons learned from the launch of Exploration Flight Test-1, the first launch of an Orion spacecraft into space in December 2014, the pressure vessel is about 500 pounds lighter and has fewer parts, according to Mike Hawes, Lockheed Martin Orion program manager.

"We learned a lot from the first flight test," Hawes said. "Exploration Mission-1 will be a demanding, rigorous mission. We're ready to start the work."

About a year from now, the Orion crew module will be powered on and prepared for all of the tests that will confirm the spacecraft is ready for flight. Orion will be integrated with the European Space Agency-provided service module that will provide the main propulsion system and power.

◀ NASA and Lockheed Martin engineers and technicians monitor the progress Feb. 2 as a crane lowers the Orion crew module pressure vessel for NASA's Exploration Mission-1 (EM-1) onto a test stand called the birdcage inside the Neil Armstrong Operations and Checkout Building high bay at Kennedy Space Center. The Orion spacecraft will launch atop NASA's Space Launch System rocket on EM-1, an uncrewed test flight, in 2018. Photo credit: NASA/Bill White





The spacecraft will be fueled and stacked atop the Space Launch System, or SLS, rocket for its historic launch.

“It’s amazing the amount of dedication we have from former space shuttle workers who are now putting together our new spacecraft with the same dedication, care and skill that they used to keep our shuttles flying safely,” astronaut Stan Love said.

The main goal of the first integrated launch of the SLS rocket and Orion spacecraft will be to demonstrate NASA’s new capability to launch future

crewed, deep-space missions to an asteroid and a journey to Mars.

Orion eventually will take NASA on a journey to Mars aboard the SLS, but first it will travel 40,000 miles beyond the moon over the course of a three-week mission as part of Exploration Mission-1, or EM-1.

At liftoff from Pad 39B, the SLS Block 1 rocket on EM-1 will provide about 8 million pounds of thrust, greater than any other rocket in the world today and comparable to that of the Saturn V. During re-entry, Orion will

travel at speeds up to 25,000 mph, withstand temperatures of 5,000 degrees F and splashdown in the Pacific Ocean off the coast of San Diego.

“Orion and the Space Launch System will allow us to be leaders in space,” said Mark Geyer, deputy center director at Johnson Space Center in Houston. “This vehicle will go further than any of the Apollo spacecraft.”

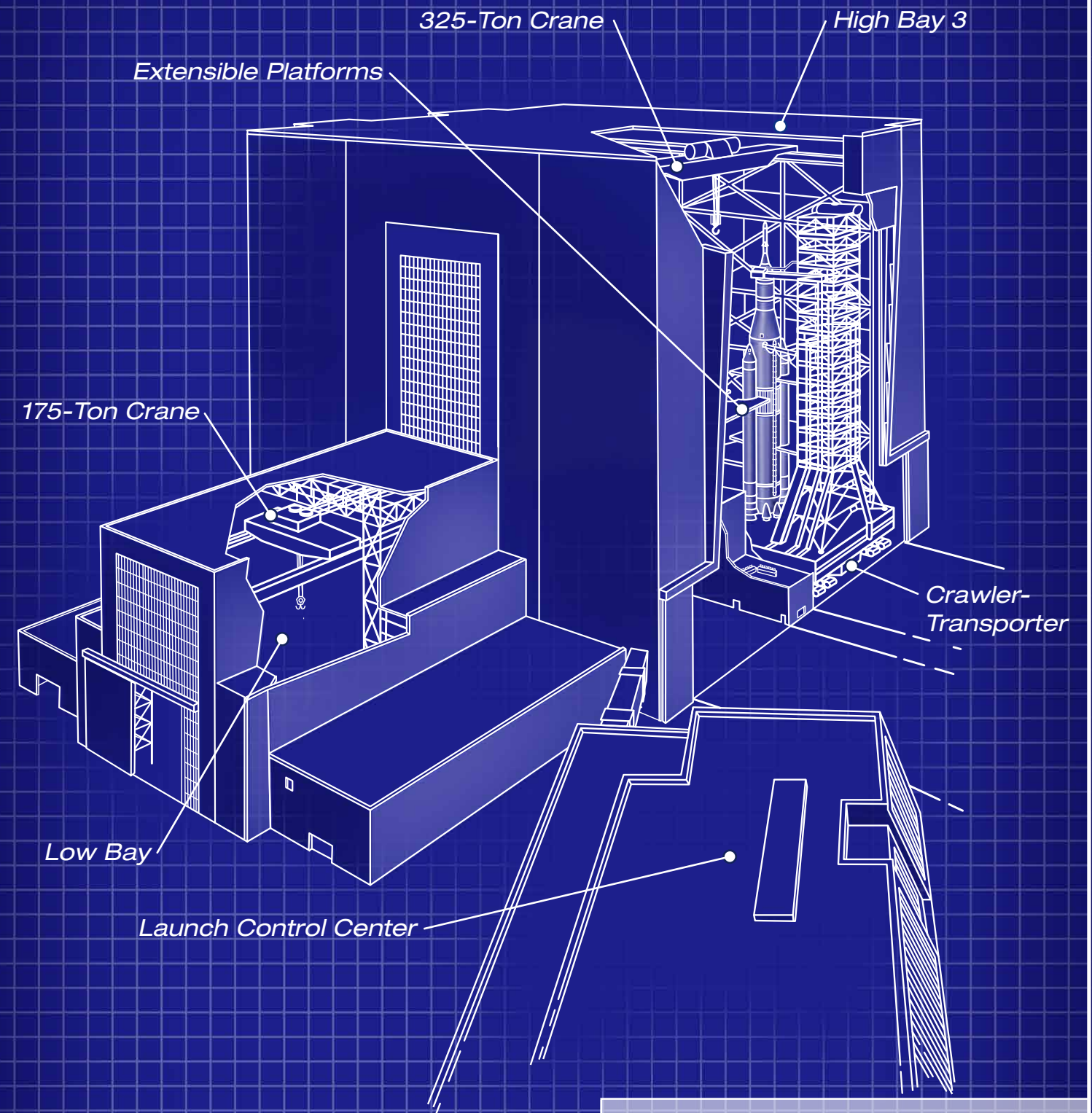
**“At Kennedy, we are going to turn the pressure vessel into a fully operational spacecraft.”**

**Scott Wilson**  
NASA Orion  
Production Manager

For more details on Orion’s place in the future of space exploration, visit <https://youtu.be/8dbjoLCmxRU>



Scott Wilson, manager of Orion Production Operations at Kennedy, speaks to members of the news media inside the Neil Armstrong Operations and Checkout Building high bay at Kennedy Space Center. To his right is NASA astronaut Stan Love. To his left are Mark Geyer, deputy director of NASA’s Johnson Space Center in Houston, and Mike Hawes, Lockheed Martin’s Orion Program manager. Photo credit: NASA/Bill White



**NASA’S VEHICLE ASSEMBLY BUILDING**

*The Power To Explore Beyond Earth’s Orbit*

The Vehicle Assembly Building, or VAB, at NASA’s Kennedy Space Center is designed to assemble space vehicles, such as the massive Saturn V and the Space Shuttle. In the near future, the Space Launch System rocket and the Orion spacecraft also will be assembled in this building that reaches 525 feet tall.





# Dragon Fire

A full-size test article of a SpaceX Crew Dragon fires its eight SuperDraco engines in a development test of its ability to land with the accuracy of a helicopter using only the thrusters. The company conducted two tethered tests attached to a crane so engineers could refine the landing software and systems on the spacecraft. SpaceX envisions returning people to Earth from space on the power of thrust instead of beneath parachutes. SpaceX, in partnership with NASA's Commercial Crew Program, is developing the Crew Dragon and Falcon 9 integrated system to take astronauts to launch astronauts to the International Space Station from the United States.

Photo credit: SpaceX

# Dream Chaser

A full-scale engineering test article of Sierra Nevada Corporation's Dream Chaser spacecraft is nearing completion leading to a second round of atmospheric evaluations at NASA's Armstrong Flight Research Center in Edwards, California. The flight testing, which calls for the Dream Chaser to be released high over California's Rogers Dry Lakebed and glide to a safe landing, will build upon an earlier free-flight test milestone that returned valuable data for the design team. Photo credit: Sierra Nevada Corporation





# Beautiful Harvest

## Flowering Zinnias on space station set stage for deep-space food crop research

BY LINDA HERRIDGE

Zinnia plants from the Veggie ground control experiment at Kennedy Space Center were harvested Feb. 11 the same way that crew member Scott Kelly harvested the zinnias growing in the Veggie system aboard the International Space Station on Feb. 14.

The ground plants didn't experience some of the same stressors as those grown simultaneously on the ISS — like unexpected fungus growth. However, some of the zinnia plants aboard the floating laboratory pulled through due to collaboration between the astronauts and the ground team at Kennedy. Ultimately, the experiment that went off-script when astronaut Scott Kelly became an autonomous gardener, provided researchers with even more information about how to effectively grow plants in space than they expected.

"I think we've learned a lot about doing this kind of experiment. We're being farmers in space," Kelly said. "I was extra motivated to bring the plants back to life."

Flowering plants will help scientists learn more about growing crops for deep-space missions and NASA's journey to Mars.

"We need to learn a tremendous amount to help develop more robust sustainable food production systems as NASA moves toward long-duration exploration and the journey to Mars," said Gioia Massa, NASA Kennedy payload scientist for Veggie.

Researchers hope to gather good data regarding long-duration seed stow and germination. Also, whether pollen could affect crew health and how having growing colorful flowering plants to grow could improve crew morale.

Veggie is the biggest plant/flower experiment to fly on the station. Experiments involving space plants have been a favorite of astronauts, especially those staying in space for long durations like Scott Kelly. According to behavioral health scientists, part of the pleasure for astronauts is just being involved in meaningful work. But crews in space aren't the only ones positively affected

Colorful ground control zinnia plants are being prepared for harvest inside the Flight Equipment Development Laboratory in the Space Station Processing Facility at Kennedy Space Center. In the background is Chuck Spern, a project engineer with Vencore on the Engineering Services Contract at Kennedy. A similar zinnia harvest was conducted by astronaut Scott Kelly on the International Space Station on Feb. 14. Photo credit: NASA/Bill White

by growing plants.

"We are sad to see them go," said Chuck Spern, a project engineer with Vencore on the Engineering Services Contract at Kennedy, "We've been caring for them for quite a while. But it's for the interest of science so we can go to Mars."

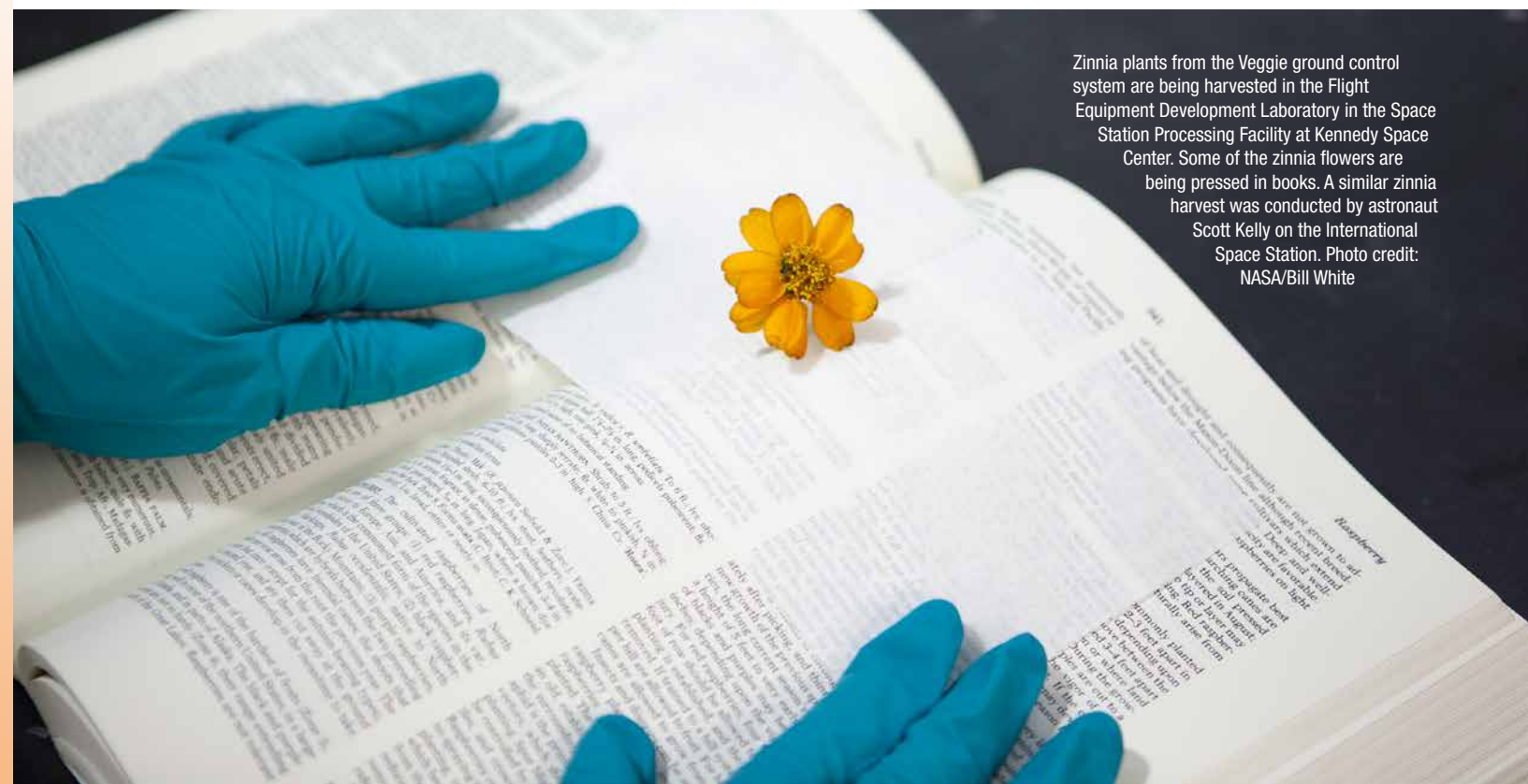
At Kennedy, Spern removed the Veggie base tray from a controlled environment chamber in the Space Station Processing Facility and moved it to the Flight Equipment Development Laboratory for harvesting.

The plant pillows containing the zinnia seeds were activated in the Veggie system on the space station and in the ground control experiment Nov. 13. The plants grew for nearly three months, much longer than the previous red romaine lettuce crop which grew for 33 days. The flowers were watered and monitored by Kelly and other crew members on the space station, and by Spern and other researchers in the control experiment on the ground.



A colorful bouquet of zinnias float aboard the International Space Station with the Earth and space seen in the background. Photo credit: NASA

During the harvest, Spern and John Carver, an integration engineer with Jacobs on the Test and Operations Support Contract, carefully cut the colorful blooms and prepared them for storage. The zinnia flower heads were preserved in three ways. Some of the older plants were harvested for their seeds and air-



Zinnia plants from the Veggie ground control system are being harvested in the Flight Equipment Development Laboratory in the Space Station Processing Facility at Kennedy Space Center. Some of the zinnia flowers are being pressed in books. A similar zinnia harvest was conducted by astronaut Scott Kelly on the International Space Station. Photo credit: NASA/Bill White





Zinnias on the International Space Station before harvest. Photo credit: NASA

dried at room temperature to allow the seeds to be tested for germination and regrowth potential. Some of the flowers were frozen at minus 80 degrees Celsius and stored for microbial assessment. Some of them were pressed.

“The flowers going to seed are a good demonstration for sustainable food crops,” said Nicole Dufour, a NASA mechanical engineer and Veggie subject-matter expert. “It’s a good example of starting with seeds and ending with seeds, which is what you need to sustain crop growth.”

The remaining plant material, plant pillows, microbial sampling swabs and water samples will be stored at minus 80 degrees Celsius for analysis. All of the samples will be compared with plants and plant pillows from the International Space Station, which will be preserved in the same way and returned to Earth on a future Commercial Resupply Services mission.

“We are learning a tremendous amount from Veggie about plants and plant-human-microbial interactions as part of NASA’s Space Biology Program,” Massa said. “And the knowledge gained on food productions helps fill gaps and mitigate food system risks.”

Massa said the zinnia crop will give researchers insights that are valuable for a number of longer duration and fruiting crops, such as tomatoes, peppers, strawberries and other staple crops such as beans and peanuts.

The next Veggie experiment, Veg-03, will be delivered to the space station on a future Commercial Resupply Services mission. The plant pillows will contain two types of seeds: ‘Outregeous’ red romaine lettuce for the crew to grow and consume, and two other sets containing a small Chinese Cabbage variety called ‘Tokyo Bekana.’

The Veggie system was developed by Orbital Technologies Corp. in Madison, Wisconsin, and tested at Kennedy before flight. Veggie, along with two sets of pillows containing romaine seeds and one set of zinnias, was delivered to the station by SpaceX on the third cargo resupply mission in April 2014.



# Going Vertical

A critical piece of large equipment was tested in February at Launch Complex 39A as SpaceX raised and lowered the transporter erector that will be used to move the Crew Dragon spacecraft atop a Falcon 9 rocket to the launch pad for missions. Standing 212 feet high — more than 20 stories — the TE, as SpaceX calls the machine, will move launch-ready rockets and spacecraft from the processing hangar at the base of the pad up to the pad surface and into a vertical position over the flame trench.

The lift and lowering of the transporter erector are part of routine tests conducted on the pad to ensure all ground systems are prepared to launch astronauts to the International Space Station. The TE is a much larger and stronger version of the erector the company uses at Space Launch Complex 40, as it will also be used for processing and launching future Falcon Heavy rockets. Photo credit: SpaceX



# Contracted Cargo

## More Florida launches on the way as NASA awards space station suppliers

BY CHERYL WARNER, STEPHANIE SCHIERHOLZ

NASA has awarded three cargo contracts to ensure the critical science, research and technology demonstrations that are informing the agency's journey to Mars are delivered to the International Space Station from 2019 through 2024. The agency unveiled its selection of Orbital ATK of Dulles, Virginia; Sierra Nevada Corporation of Sparks, Nevada; and SpaceX of Hawthorne, California, to continue building on the initial resupply partnerships with two American companies.

These Commercial Resupply Services, known as CRS-2, contracts are designed to obtain cargo delivery services to the space station, disposal of unneeded cargo, and the return of research samples and other cargo from the station back to NASA.

"Few would have imagined back in 2010 when President Barack Obama pledged that NASA would work 'with a growing array of private companies competing to make getting to space easier and more affordable,' that less than six years later we'd be able to say commercial carriers have transported 35,000 pounds of space cargo

(and counting!) to the International Space Station — or that we'd be so firmly on track to return launches of American astronauts to the space station from American soil on American commercial carriers. But that is exactly what is happening," said NASA Administrator Charles Bolden.

The contracts, which begin upon award, guarantee a minimum of six cargo resupply missions from each provider. The contracts also include funding space station integration, flight support equipment, special tasks and studies, and NASA requirement changes.

Selecting multiple providers assures access to the space station so crew members can continue to conduct the vital research of the National Lab. Awarding multiple contracts provides more options and reduces risk through a variety of launch options and mission types, providing the space station's program a robust portfolio of cargo services that will be necessary to maximize the utility of the station.

NASA has not yet ordered any missions, but will make a total of six selections from each menu of mission options at fixed prices, as

needed. Each task order has milestones with specified amounts and performance dates. Each mission requires complex preparation and several years of lead time. Discussions and engineering assessments will begin soon, leading to integration activities later this year to ensure all space station requirements are met, with the first missions beginning in late 2019.

Each of the three companies selected submitted proposals that included launches from Florida, and one provided options for both Virginia and Florida. As a 21st century multiuser spaceport, Kennedy Space Center is one of the two cargo gateways to the space station from the United States. Much of the science and supplies destined for the space station comes through Kennedy before launching from nearby Cape Canaveral. Both types of pressurized cargo return and disposal as well as unpressurized cargo delivery and disposal missions proposed by Sierra Nevada Corporation proposed would launch from Florida. Both of SpaceX's proposed missions, pressurized cargo delivery and return as well as unpressurized cargo delivery and disposal, would launch from Florida. Orbital ATK proposed two types of standard missions, and one type of its pressurized cargo missions could launch from Florida. Another mission type could launch from Wallops Flight Facility in Wallops Island, Virginia. NASA will order missions based on its needs, and that can include any combination of orders for missions from Florida and/or Virginia.

"These resupply flights will be conducted in parallel with our Commercial Crew Program providers' flights that enable addition of a seventh astronaut to the International Space Station. This will double the amount of crew time to conduct research," said Julie Robinson, chief scientist for the International Space Station Program. "These missions will be vital for delivering the experiments and investigations that will enable NASA and our partners to continue this important research."

For 15 years, humans have been living continuously aboard the space station to advance scientific knowledge and demonstrate new technologies, making research breakthroughs not possible on Earth that also will enable long-duration human and robotic exploration into deep space. A truly global endeavor, more than 200 people from 15 countries have visited the unique microgravity laboratory that has hosted more than 1,700 research investigations from researchers in more than 83 countries.



Orbital ATK's Cygnus cargo spacecraft. Photo credit: Orbital ATK



Sierra Nevada Corporation's Dream Chaser spacecraft. Image credit: Sierra Nevada Corporation



SpaceX's Dragon cargo spacecraft. Photo credit: NASA



For more information on the space station and its crew members, visit: <http://www.nasa.gov/station>

ISS



# Lap in an MRAP

NASCAR driver Carl Edwards visited Kennedy Space Center and slid behind the wheel of an entirely different kind of car: a Mine-resistant, Ambush-protected vehicle better known as MRAP.

The agency's Ground Systems Development and Operations Program selected the MRAP to serve as an upgraded version of an armored escape vehicle that would allow astronauts to evacuate the launch pad in the event of an emergency.

While at Kennedy, Edwards stopped by the massive Vehicle Assembly Building and Launch Pad 39B. Both facilities are being prepared to support assembly and launch of NASA's next-generation heavy-lift rocket, the Space Launch System.

Photo credit: NASA/Bill White



*Thanks to NASA, radial tires have significantly better traction and tread life. A remarkable lightweight fibrous material, five times stronger than steel, was developed by NASA and a chemical company for use in Viking space vehicle parachute shroud lines. The manufacturer who supplied tires for Apollo 14 later applied the material to radials for automobiles.*

To learn more about NASA spinoffs, visit <http://go.nasa.gov/1XKxRcM>



# Safe Landing



## Engineer ensures commercial crew craft will have smooth touch down

BY STEVEN SICELOFF



Jeff Thon

Skydivers know what it's like to depend on a parachute. That is why it helps them that one of the engineers NASA depends on to assess the landing systems of the next generation of human-rated spacecraft is a skydiver with 14 years of experience working with parachutes on launch systems.

"I used to jump out of airplanes," said Jeff Thon, who is a subsystem manager for landing and recovery systems for NASA's Commercial Crew Program. "I started skydiving in 1998 and jumped actively until 2008 and recently picked it back up a couple of years ago when my kids all left the house."

Thon worked with the solid rocket boosters during the space shuttle era. The boosters carried parachutes in their noses so they would float down to the ocean and be recovered for another launch. Thon started supporting the development of commercial crew systems in 2010. His shuttle experience was invaluable for NASA's Commercial Crew Program because some of the early designs for privately built spacecraft relied on parachutes for the safe return of the crew aboard. All the spacecraft designs, including those with wings, had to be evaluated closely as each phase of development progressed.

"It was early enough in the development program that I could come in green and start to get a grip on what the system looked like and how it should perform," Thon said, "so it was, go learn capsule parachutes."

When NASA awarded the final development and certification

contracts to Boeing and SpaceX in 2014, the CST-100 Starliner and Crew Dragon, respectively, featured capsule designs returning under parachutes to land on either land or water.

Almost six years after starting work with Commercial Crew, Thon and the landing systems teams are starting the certification and qualification phase of testing and evaluation for the Boeing and SpaceX spacecraft. That means Boeing and SpaceX are evaluating the systems each plans to use for their respective spacecraft. NASA's role is to ensure the systems are safe to take astronauts to and from the International Space Station.

The mechanisms on both the Starliner and Crew Dragon have seen tests already to show their designs were progressing and were safe. As testing continues, spacecraft mockups and boilerplate models that are nearly identical to an operational craft will be used to test the performance of the systems. Engineers also are seeing how the parachutes behave in the turbulence and rapid changes

that take place in the few seconds after the parachutes are released from their compartments.

"Parachutes don't lend themselves well to computer modeling," Thon said. "Having a bag of 'chutes come out at 300 mph is darn near impossible to model with any kind of computer we have today, so we have to test."

Testing and real-world results have to be performed to adequately show how a

landing system will behave, Thon said.

"The team is reviewing the rigorous testing campaign for both Boeing and SpaceX against the standards expected for human spaceflight," Thon said. A system's heritage and history plus how its similarity to other successful parachute systems such as Orion are considered during the evaluation.

The testing isn't just to see how the parachutes will work, it also helps engineers lay out steps for the spacecraft and its crew to take in

Four red-and-white parachutes unfurled high above the desert near Coolidge, Arizona, recently during a test of the system that initially will be used to safely land SpaceX's Crew Dragon spacecraft carrying astronauts back from the International Space Station. The test used a mass simulator as the weight of the spacecraft connected to the parachute system.

The mass simulator and parachutes were released thousands of feet above the ground from a C-130 cargo aircraft. This test evaluated the four main parachutes, but did not include the drogue chutes that a full landing system would utilize.

Initially, the spacecraft will splash down safely in the ocean under parachutes, but ultimately the company wants to land the vehicle on land propulsively using eight SuperDraco engines. SpaceX tested its propulsive land landing ability in Texas in November.

Photo credit: SpaceX.

**"Having a bag of 'chutes come out at 300 mph is darn near impossible to model with any kind of computer we have today, so we have to test."**

Jeff Thon  
Commercial Crew Program





A mockup of Boeing's CST-100 Starliner spacecraft, in development in partnership with NASA's Commercial Crew Program, splashes into a 20-foot-deep Hydro Impact Basin at NASA's Langley Research Center in Hampton, Virginia, during certification and qualification testing of the spacecraft's landing systems design. While the Starliner is designed for land-based returns, it is important for engineers to understand how the spacecraft and its systems would perform in emergency water landing scenarios. The Starliner is one of two commercial spacecraft in development to launch astronauts to the International Space Station from the United States. Photo credit: NASA/David C. Bowman

a number of emergency scenarios.

There have been parachute-related failures in spaceflight history, including the Soviet-era Soyuz-1 accident in which cosmonaut Vladimir Komarov perished when his Soyuz parachute system malfunctioned during the return to Earth in 1967. NASA's Genesis sample return probe, which carried no crew, crashed into the Utah desert after its parachutes failed to deploy in 2004.

However, NASA has a long history of success with parachute landing systems. Mercury, Gemini and Apollo spacecraft all used

parachutes to slow down after re-entry and touch down in the water safely. The space shuttle boosters were recovered intact thanks to parachutes, and the shuttle used a drag chute at landing. That expertise is being leveraged to ensure these systems are safe.

Both Boeing and SpaceX have already conducted demonstration drop tests during earlier phases of development. Now at the certification and qualification phase, when engineers declare the designs safe for use, the testing is more detailed. The test articles carry many more sensors to gather higher fidelity data. All of that data is fed into computers for

exacting analysis, especially of those first few seconds of deployment.

"We are aiming to put a check in the box for flight tests and then crewed orbital flight tests," Thon said.

Although the parachutes are an important aspect to a safe landing, Thon also is evaluating the air bags Boeing plans to use to soften the stop of its Starliner when it touches down.

As with the parachutes, the air bags have to be tested to make sure they will inflate like they need to and that they don't

unexpectedly cause damage to the spacecraft.

Thon said the development process is quite a bit different from any other spacecraft the agency has worked on for its astronauts.

"What I love about Commercial Crew is that it's a dedicated group of engineers both on the NASA and on the partners' side," Thon said. "We both work together and use innovative methods to return astronauts to the International Space Station using American spacecraft."



# Tour de KSC

More than 650 employees and their guests came out to Kennedy Space Center on Feb. 27 to take a bike tour of the multiuser spaceport. During the event, bike riders could choose from three different routes of varying length. All routes had unique photo stops where riders could see, firsthand, what is being worked on at the center.

Photo credit: Kim Shiflett





# Sittin' with Suni Q&A

## Commercial Crew astronaut Suni Williams shares her insight



**A**stronaut Suni Williams is one of four selected to train closely with Boeing and SpaceX as they develop a new generation of human-rated spacecraft in partnership with NASA's Commercial Crew Program. Williams, Bob Behnken, Eric Boe and Doug Hurley will spend considerable time working with the new spacecraft development teams to begin piloted flight tests in 2017. Williams talked recently about some of the expectations of the Commercial Crew Program, which is working with Boeing and SpaceX on their CST-100 Starliner and Crew Dragon spacecraft, respectively, in a unique way focused on safety, reliability and cost-effectiveness. A veteran of two long-duration missions to the International Space Station, Williams also talked about some of the things that make her career enjoyable and what it takes to become an astronaut.

### Q WHAT WILL MAKE COMMERCIAL CREW A SUCCESS?

*We're heading down this exciting path of Commercial Crew. It's going to be successful and put to the test when we launch from Kennedy Space Center. Both companies, Boeing and SpaceX, are working hard already, starting to bend metal and actually make spacecraft. I'm excited to be part of the first couple of people who will probably fly one of these spacecraft so already we've started down the path. I think the test will be when we put those spacecraft on the launch pad and are ready to light them off and send them to the space station.*

### Q WHAT EXCITES YOU ABOUT THE COMMERCIAL CREW APPROACH TO SPACECRAFT DEVELOPMENT?

*We have the opportunity as the Commercial Crew cadre to go to both Boeing and SpaceX and check out what they're doing and how they're coming along with their spacecraft. I*

*think what's really exciting is seeing the new technologies that they're incorporating into their spacecraft. These are things that are much different from both space shuttle and Soyuz, because they're taking advantage of the technology from the last two decades or so. Some of the ideas are brand new, it makes us think out of the box from how we've done spacecraft and how we've flown spacecraft before. So I'm pretty excited to see these new technologies be incorporated into these new spacecraft.*

### Q WHY USE TEST PILOTS FOR THE FIRST COMMERCIAL CREW MISSIONS?

*This will be the first time in a generation that we are going to launch a new spacecraft. I think what goes hand-in-hand with putting the right people on the first couple of missions to really shake out the spacecraft and make sure that they'll be ready to fly for the next generation of folks who are going to be flying these for quite some time. Part of that is*

*putting test pilots on the first couple missions. As part of the test pilot curriculum, we learn a lot about the rigors and the methodology of testing in a very stepwise fashion, looking to approach the boundaries step by step and not jumping out too fast too quickly and exceeding any boundaries of the vehicle or the human in the loop.*

*I think part of the methodology of selecting test pilots for the first couple flights is based on the rigors that we learned in test pilot school. So to look at these spacecraft in a wide variety of aspects and really go down the path and make sure they're really good for the next generation.*

### Q WILL ONLY TEST PILOTS BE ABLE TO FLY THESE SPACECRAFT?

*After the first couple missions of each spacecraft, I don't think we're going to have to have test pilots as the prime operator of either of the commercial crew vehicles. I think*

*the idea is to make sure all of the bugs are worked out as much as possible and be able to turn those spacecraft over to anybody in the astronaut office to be able to fly.*

### Q The Commercial Crew missions will allow astronauts twice as much time for research. Describe conducting experiments on the International Space Station.

*Conducting research on the space station is very interesting and sometimes challenging. It's a whole different kind of laboratory than here on the ground. Of course, we're doing similar experiments than we do on the ground but we have to do them in space which means there's different processes, different materials, there's different considerations — things float around — so you have to be a little bit worried how you're actually putting the experiment together. Sometimes they take a little bit longer, sometimes they're just observational experiments where we set up and then we make observations just using the background of microgravity to see how it affects the experiment. But it's challenging, so one more crewmember up on the space station helping out is going to probably double the amount of space research that we're doing right now.*

### Q WHAT DO YOU TAKE WITH YOU WHEN YOU GO TO SPACE?

*So I've been to space two times and I always like to take something that reminds me of home. My first mission I wasn't sure how much stuff I could take or what I could take, you know it's always the first time, so I took a little paper cutout of my dog and I had him inside of my crew notebook. My second time I knew a little more about how much space I had so I had a little stuffed animal of him, so I got to have him inside my sleep station and slept with him every night.*

*For the next mission, I don't know, I don't think I can take anything bigger than the stuffed animal I already had so I might have to get one more stuffed animal. I actually left my little stuffed guy up there with one of my crewmates who was staying on the space station so this time if I take a stuffed Gorby*

*I think I might have to bring him back home with me.*

### Q WHAT DOES IT MEAN TO WORK AT NASA AND BE AN ASTRONAUT?

*Working for NASA and being an astronaut is really exciting, and it's fun, first and foremost. I have never felt like I have "a job." I go to work every day and it's something new and exciting and sometimes it means actually getting on a rocket and going to space. There are a lot of cool things we do and it's not only just us who are astronauts who are working for NASA. It's people who are doctors and scientists and engineers and veterinarians who all work together to make up a space mission that eventually allows us to get up on a rocket and go do experiments in space up on the space station.*

### Q WHEN DID YOU BEGIN TO THINK YOU WANTED TO BE AN ASTRONAUT?

*When I was a kid I was thinking about what I wanted to do when I grow up, I think everybody thinks about that. My dad's a doctor, so I was thinking maybe I want to be a veterinarian, but I really just didn't know, honestly, when I was a little kid. I didn't even really know when I was graduating from high school. So I had the opportunity to go to the Naval Academy, and after that I learned how to fly airplanes and helicopters. That led me to be interested in engineering and being interested in learning how to test fly aircraft. Later, test pilot school brought me down to*

*NASA's Johnson Space Center and that's the first time I ever met an astronaut, John Young. He talked about landing on the moon and I thought, wow, he had to fly something like a helicopter to land on the moon and maybe I have those skills too. That was the very first time I thought about being an astronaut.*

### Q WHAT SHOULD THIS NEW CLASS OF ASTRONAUTS EXPECT?

*We're getting ready to have a new class of astronauts, a new selection in 2017. I'm so excited for them, they're going to have a big path of stuff to do in front of them. First of all, they'll probably be long-duration astronauts living on the International Space Station flying up there on commercial crew vehicles or Soyuz and then probably flying on the Orion spacecraft that's going to take them farther than low-Earth orbit. So I would suggest for them, of course, to prepare and get ready.*

### Q WHAT ADVICE DO YOU HAVE FOR ANYONE SELECTED TO BECOME AN ASTRONAUT?

*So for the next group of astronauts that's going to be selected in 2017, I would give you a couple of pieces of advice: First of all, buckle your seatbelt, it's going to be a wild and crazy ride. You're going to be working with teams all over the world and you're going to be going to places that are just beyond what we are doing today. So, get ready for that adventure, stay healthy and get ready.*







Workers gather next to an exhibit that includes a United States flag and a plaque of Dr. Maya Angelou's writing, "A Brave and Startling Truth," at NASA's Space Station Processing Facility at Kennedy Space Center on Feb. 11. The flag, presented to NASA on behalf of the men and women of Lockheed Martin, and the plaque were flown on the Orion Exploration Flight Test-1 on Dec. 5, 2014. The employees are gathered around zinnia flowers that were harvested as part of the ground control for the experiment conducted aboard the space station. Photo credit: NASA/Bill White



Workers gather next to an exhibit that includes a United States flag and a plaque of Dr. Maya Angelou's writing, "A Brave and Startling Truth," inside the Vehicle Assembly Building in front of the crawler-transporter at Kennedy Space Center on Feb. 11. The crawler transporter eventually will carry the SLS with the Orion spacecraft atop it to Launch Pad 39B to begin deep-space exploration missions. The flag, presented to NASA on behalf of the men and women of Lockheed Martin, and the plaque were flown on the Orion Exploration Flight Test-1 on Dec. 5, 2014. Photo credit: NASA/Kim Shiflett

# Words of Inspiration

## Traveling exhibit touches hearts of Kennedy workers

From watching a rocket launch at NASA's Kennedy Space Center to reading poetry, inspiration can come in many forms. While Dr. Maya Angelou was alive, many of her works inspired us and some even took our breath away, just like witnessing millions of pounds of thrust lifting a rocket toward the heavens.

Recently, a United States flag and a poem by Dr. Maya Angelou went on display at various locations around Kennedy Space Center. The United States flag was presented to NASA on behalf of the men and women of Lockheed Martin by Marilyn Hewson and Rick Ambrose.

Along with the flag, the Angelou Family "Cage Foundation" gifted a plaque of Dr. Angelou's writing, "A Brave and Startling Truth" to NASA, which NASA Administrator Charlie Bolden accepted on

behalf of the agency. Angelou, who died in 2014, was a poet and award-winning author known for her numerous poetry and essay collections. Both the flag and the plaque were flown on the Orion Exploration Flight Test-1 on Dec. 5, 2014. The two items are a traveling exhibit that will spend a month at each NASA center. The flag and poem will remain on display in the main lobby of Kennedy's Headquarters Building until March 11.

The poem was written and delivered by Dr. Angelou in honor of the 50th anniversary of the United Nations, a fitting tribute to Orion's first flight.

All the stops on the exhibit tour showcased employees' accomplishments toward making the journey to Mars. Here at Kennedy, Angelou's writings never rang more true:

*When we come to it*

*We must confess that we are the possible*

*We are the miraculous, the true wonder of this world*

*That is when, and only when*

*We come to it.*



Workers gather next to an exhibit that includes a United States flag and a plaque of Dr. Maya Angelou's writing, "A Brave and Startling Truth," at the Neil Armstrong Operations and Checkout Building at Kennedy Space Center on Feb. 11. The O&C is housing the Orion spacecraft where it is being outfitted with the systems and subsystems necessary for flight, including its heat-shielding thermal protection system. The flag, presented to NASA on behalf of the men and women of Lockheed Martin, and the plaque were flown on the Orion Exploration Flight Test-1 on Dec. 5, 2014. Photo credit: NASA/Bill White



Workers gather next to an exhibit that includes a United States flag and a plaque of Dr. Maya Angelou's writing, "A Brave and Startling Truth," at NASA's Swamp Works Lab at Kennedy Space Center on Feb. 11. The Swamp Works labs is home to the RASSOR 2.0 prototype. The Regolith Advanced Surface Systems Operations Robot is among the soil excavators being built and tested to mine regolith in space. The flag, presented to NASA on behalf of the men and women of Lockheed Martin, and the plaque were flown on the Orion Exploration Flight Test-1 on Dec. 5, 2014. Photo credit: NASA/Bill White



# IN MEMORIAM



EDGAR MITCHELL

1930-2016

## Edgar Mitchell Followed ‘The Way of the Explorer’

**A**pollo astronaut Edgar Mitchell, one of the few humans to walk on the moon, died Feb. 4, 2016, in West Palm Beach, Florida, at the age of 85. It was the eve of the 45th anniversary of his lunar landing.

Kennedy Space Center Director Bob Cabana, a former astronaut and space shuttle mission commander, spoke of Mitchell on hearing of the passing of Apollo 14’s lunar module pilot.

“It is with sadness that the Kennedy Space Center recognizes the passing of another Apollo astronaut and American hero, Edgar Mitchell,” he said. “We will always think fondly of him when we pass by the Apollo 14 command module in the Saturn V facility. Our hearts and prayers go out to his family members.”

NASA Administrator Charlie Bolden also remembered Mitchell who joined Apollo 14 commander Alan Shepard Jr. in the lunar

◀ Apollo astronaut Edgar Mitchell in front of a graphic of the mission patch. Photo Credit: NASA



Retired Apollo astronaut Edgar Mitchell waves to spectators from a vintage Chevrolet Corvette during a commemorative parade in Cocoa Beach, Florida, on May 7, 2011. Photo credit: NASA/Kim Shiflett

module Antares as it touched down in the moon’s Fra Mauro highlands on Feb. 5, 1971.

“On behalf of the entire NASA family, I would like to express my condolences to the family and friends of NASA astronaut Edgar Mitchell,” he said in a statement. “As a member of the Apollo 14 crew, Edgar is one of only 12 men to walk on the moon and he helped to change how we view our place in the universe.”

A frequent visitor to Florida’s Space Coast, Mitchell made many trips to the Florida spaceport for training prior to the Apollo 14 launch. Additionally, he was inducted into the U.S. Astronaut Hall of Fame on Oct. 4, 1997, and after that, returned for many of the organization’s ceremonies.

Mitchell was born Sept. 17, 1930, in Hereford, Texas, but considered Artesia, New Mexico, his hometown. He graduated with a bachelor’s degree in Industrial Management from Carnegie Mellon University in Pittsburgh in 1952.

After being commissioned an officer in the U.S. Navy, Mitchell completed flight training in July 1954 at Hutchinson, Kansas, and was designated as a Naval aviator. He went on to accumulate 5,000 hours flight time, including 2,000 hours in jet aircraft

While serving in the Navy, Mitchell went on to earn a bachelor’s in aeronautics from the U.S. Naval Postgraduate School in 1961. Later, he was awarded a doctorate in aeronautics and astronautics from the Massachusetts Institute of Technology in 1964.

NASA selected Mitchell as an astronaut in 1966. Mitchell was drawn to spaceflight by President John F. Kennedy’s call to send astronauts to the moon.

“That’s what I wanted, because it was the bear going over the mountain to see what he could see and what you could learn,” Mitchell said after Kennedy announced the moon program. “I’ve

been devoted to that, to exploration, education and discovery since my earliest years, and that’s what kept me going.”

Mitchell served on the support crew for Apollo 9 and as backup lunar module pilot for Apollo 10. He worked in the lunar module simulator at the Johnson Space Center during Apollo 13, developing procedures that would bring the crew of that crippled spacecraft home.

For Apollo 14, Mitchell and America’s first person in space, Alan Shepard, were assigned to traverse the lunar surface to deploy scientific instruments and photograph the lunar surface and any deep space phenomena. The mission’s command module pilot, Stuart Roosa, remained in lunar orbit while Mitchell explored the moon’s Fra Mauro highlands.

Mitchell and Shepard collected 94 pounds of lunar rock and soil samples that were distributed across 187 scientific teams in the United States and 14 other countries for analysis.

In his 1996 book, “The Way of the Explorer,” Mitchell wrote, “There was a sense that our presence as space travelers, and the existence of the universe itself, was not accidental but that there was an intelligent process at work.”

Mitchell retired from NASA and the U.S. Navy in 1972 and founded the Institute of Noetic Sciences in 1973, organized to sponsor research in the nature of consciousness.

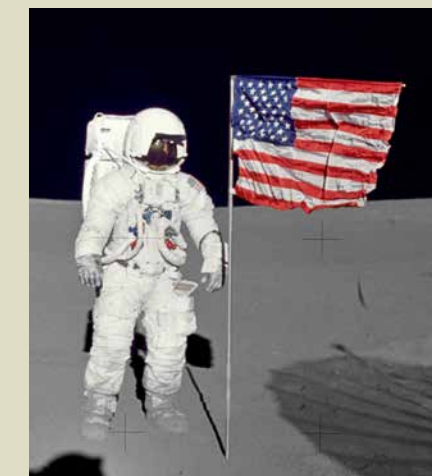
In 1984, he co-founded the Association of Space Explorers, an international organization for all who “share experience of space travel.” The mission of this organization is to provide a new understanding of the human condition resulting from the epoch of space exploration.

In an interview for NASA’s oral history program in 1997, Mitchell commented on what spaceflight meant to him.

“To me, that was the culmination of my being,” he said, “and what can I learn from this? What is it we are learning? That’s important, because I think what we’re trying to do is discover ourselves and our place in the cosmos and we don’t know. We’re still looking for that.”

Mitchell lived in Palm Beach County, Florida, since 1975. He is survived by four daughters, Karlyn Mitchell, Elizabeth Kendall,

Kimberly Mitchell, Mary Beth Johnson; a son, Paul Mitchell; and nine grandchildren. His son Adam Mitchell died in 2010.



Apollo 14 Lunar Module Pilot Edgar Mitchell stands by the deployed U.S. flag on the lunar surface during the mission’s first spacewalk. He was photographed by Mission Commander Alan Shepard Jr. Photo credit: NASA



# PROJECT GEMINI

PART 5



Gemini VIII Command Pilot Neil Armstrong, left, and Pilot David Scott, stand in front of a radar antenna during a photo session at Cape Kennedy Air Force Station. Photo credit: NASA

## Gemini's first docking turns into wild ride in orbit

BY BOB GRANATH

In early 1966, Gemini VIII chalked up another crucial spaceflight technology milestone for the United States. But the triumph quickly became an in-flight emergency, testing NASA's quick-thinking skills to bring the astronauts safely home.

The crew of Gemini VIII was the first to link two spacecraft together in Earth orbit. This milestone would prove vital to the success of future moon landing missions. Catching up with already-orbiting spacecraft also has been essential during missions to the International Space Station.

Command pilot Neil Armstrong and pilot David Scott flew the most ambitious space mission to date. On the fourth revolution of the three-day flight, they were to rendezvous and perform the first docking with the separately launched Agena. Scott also was scheduled to perform a spacewalk of more than two hours to retrieve an experiment from the front of the Gemini's spacecraft adapter and activate a micrometeoroid experiment on the Agena. For further tests, Scott then would return to the Gemini and don an Extravehicular Support Pack stored at the back of the spacecraft adapter.

A former Naval aviator, Armstrong was a member of the second group of NASA astronauts. As a test pilot, he flew the X-15 rocket plane at Edwards Air Force Base, California. He went on to command Apollo 11 in 1969, during which he became the first person to walk on the moon.

A U.S. Air Force pilot, Scott was the first member of the third group of astronauts to fly in space. He later was command module pilot on the Apollo 9 flight in 1969 and commander of the Apollo 15 lunar landing mission in 1971.

Gemini VIII's dual launchings took place on March 16, 1966. Coincidentally, it was the 40th anniversary of Dr. Robert Goddard's demonstration of the world's first liquid-propellant rocket.

Then Kennedy Space Center Deputy Director for Launch Operations, Merritt



The Atlas Agena target vehicle for the Gemini VIII mission lifts off from Launch Pad 14 at Cape Kennedy at 10 a.m. on March 16, 1966. Photo credit: NASA

Preston, called the Gemini VIII mission one of the most complex countdowns ever conducted. He explained that there were multiple counts running concurrently involving both the Atlas Agena and Gemini Titan rockets and spacecraft. Additionally, operations were coordinated between Cape Kennedy (now Cape Canaveral) Air Force Station, the Eastern Test Range, Mission Control in Houston and the ground tracking network around the world.

The Agena lifted off at 10 a.m. EST from Launch Pad 14 at the Cape atop an Atlas rocket. An hour and 41 minutes later,

Gemini VIII was boosted by a Titan II from Pad 19 just north of the Atlas launch complex.

The successful countdown brought high praise from Kennedy Director Kurt Debus. "What the nation could not see was the matchless coordination and competence demonstrated by two launch teams counting down simultaneously these sophisticated vehicles and spacecraft," he said.

Gemini VIII's orbital chase was on.

Three hours, 48 minutes into the mission, Armstrong and Scott trailed the Agena by 179 miles. Back in Mission



Control Houston, spacecraft communicator Jim Lovell asked the crew for an update.

“Do you have solid radar lock with the Agena?” said Lovell, who flew on Gemini VII three months earlier.

“That’s affirmative, we have solid radar lock,” said Armstrong, while passing over the Tananarive (now Antananarivo), Madagascar, tracking station.

This was good news as it confirmed the Gemini spacecraft rendezvous radar instruments were tracking the Agena as planned.

As Armstrong and Scott closed in, they spotted the silver target rocket in the distance.

“OK we’ve got a visual on the Agena at 76 miles,” said Armstrong.

Since he could see the Agena, Armstrong judged his braking action by eye as Scott called out radar range and the closing rates. Soon the second rendezvous in the Gemini program had

been achieved.

“Houston, this is Gemini VIII we’re station-keeping with the Agena at 150 feet,” Scott said.

The 35-minute fly-around allowed the astronauts to take a close-up look at the Agena and determine that it was safe to link up with the orbiting spacecraft.

Off the coast of South America, Keith Kundel was the spacecraft communicator onboard the USNS Rose Knott Victor tracking ship passing along direction from Mission Control.

“OK, Gemini VIII we have TM (telemetry) solid,” he said. “You’re looking good on the ground. Go ahead and dock.”

“Flight, we are docked,” Armstrong radioed back. “It was a real smoothie.”

Things had gone well up to that point. Shortly after docking, Lovell had a message from Mission Control Houston just before the spacecraft passed out of communications range.

“If you run into trouble, and the attitude control system of the Agena goes wild, just send in command 400 to turn it off and take control of the spacecraft,” he said.

The Agena was designed to obey orders from both the Gemini spacecraft and ground control. The Agena soon started a command program stored in its internal system. This instructed the Agena to turn the two spacecraft, but Scott noticed they were moving the wrong direction.

“Neil, we’re in a bank,” he said.

Armstrong used the Gemini’s orbital attitude and maneuvering system, or OAMS, thrusters to stop the tumbling. However, the roll immediately began again, and Gemini VIII was out of range of ground communications.

As Armstrong worked to regain control of the spacecraft, he noticed that the OAMS propellant was below 30 percent, an indicator that a Gemini spacecraft thruster might be the problem. Scott cycled the Agena switches off and on. Nothing helped.

Although it was not confirmed until later, a yaw OAMS thruster was firing erratically, later believed to be due to a short circuit in the wiring.

Not knowing, the crew’s first reaction was to blame the Agena. So Scott pushed the undock button, and Armstrong backed Gemini away from the Agena.

Without the added mass of the Agena, the Gemini’s rate of spin began to quickly accelerate. Soon after, Gemini VIII came in range of the tracking ship USNS Coastal Sentry Quebec, stationed southwest of Japan.

“We have serious problems here,” Scott said. “We’re tumbling end over end. We’re disengaged from the Agena.”

A surprised James Fucci, spacecraft communicator aboard the ship, asked what the problem was.

“We’re rolling up and we can’t turn anything off,” Armstrong said.

As the spin rate approached one revolution per second, the astronauts’ vision became blurred. The tumbling needed

to be stopped.

Armstrong’s quick thinking led him to turn off the entire OAMS system and then use the re-entry control system, or RCS, thrusters on the nose of the spacecraft to regain command of Gemini VIII and stop the spin.

In the meantime, John Hodge was in his first mission as chief flight director in the control center in Houston. He had to make some quick decisions too.

While problems had come up on earlier U.S. spaceflights, crews and ground controllers found a way to complete the missions. In this case, Hodge knew Armstrong used almost 75 percent of the re-entry maneuvering propellant to stop the spin. The decision was made to follow the mission rules that dictated once the RCS was activated, the crew must be brought home.

Hodge decided to have Gemini VIII re-enter after one more orbit and land within range of the secondary recovery forces. The U.S. Navy destroyer USS Leonard Mason was requested to head toward the new landing site 620 miles south of Yokosuka, Japan.

Splashdown occurred within two miles of the predicted impact point 10 hours, 41 minutes after liftoff. To support the recovery, several aircraft raced to the landing zone from Naha Air Base, Okinawa, and Tachikawa Air Base, Japan. Once the Gemini VIII spacecraft was spotted in the water, three U.S. Air Force parascuers jumped from an aircraft into the sea to attach a flotation collar to the capsule and assist Armstrong and Scott while waiting for pickup by the crew of the Mason.

Back in Mission Control, the flight control team performed maneuvers with the Agena to see how it reacted to commands from the ground. Since things went well, the Agena was left in orbit and served as a passive rendezvous target for the Gemini X mission later that year.

In the post-flight investigation, no conclusive reason for thruster malfunction was found. However, for future missions, a master switch was added to the Gemini spacecraft to make it possible for



On March 17, 1966, Gemini VIII astronauts Neil Armstrong and David Scott sit in their spacecraft while waiting for the arrival of the recovery ship, the USS Leonard Mason. They are assisted by three U.S. Air Force parascuers men. The overhead view shows the Gemini VIII spacecraft with the yellow flotation collar attached to stabilize the spacecraft in choppy seas. Photo credit: NASA

astronauts to turn off individual elements of a system not working properly.

Following the flight, Debus congratulated those supporting the mission and NASA’s skilled handling of the in-flight emergency.

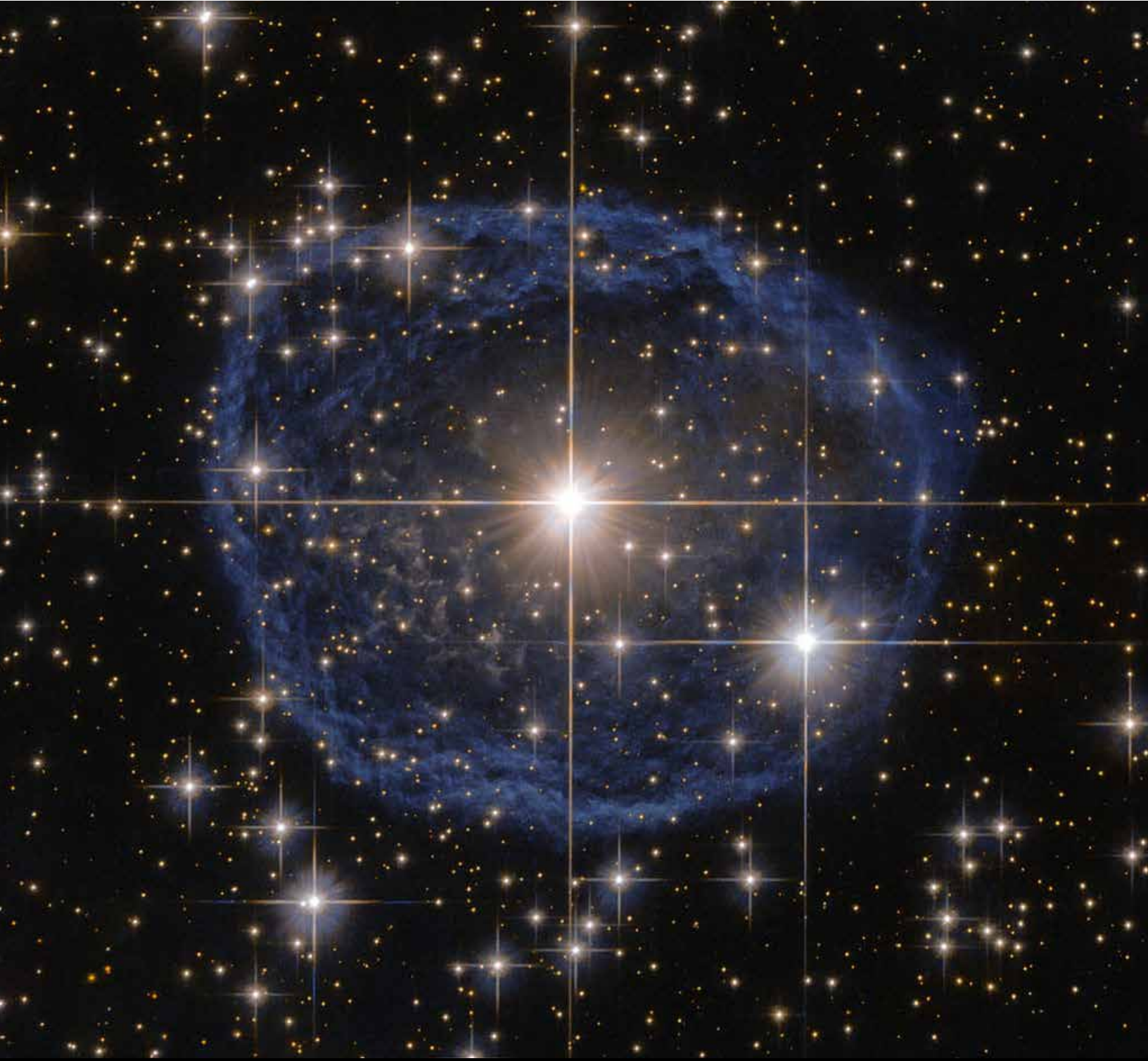
“The successful launch of the Atlas Agena target vehicle and Gemini VIII within a period of 101 minutes was a suburb performance leading up to the first successful rendezvous and docking maneuver,” he said. “Our pride in this achievement was tempered, however, by the deep concern for the crew during the later hours of an historic day. That astronauts Armstrong and Scott achieved a completely successful re-entry gives the nation cause for rejoicing in their heroism and skill.”

*EDITOR’S NOTE: This is the fifth in a series of feature articles marking the 50th anniversary of Project Gemini. The program was designed as a steppingstone toward landing on the moon. The investment also provided technology now used in NASA’s work aboard the International Space Station and planning for the Journey to Mars. In June, read about an orbital rendezvous with an “angry alligator.” For more, see “On the Shoulders of Titans: A History of Project Gemini.”*



The nose of Gemini VIII approaches the docking collar of the Agena target vehicle as Neil Armstrong and David Scott complete the world’s first link-up between two spacecraft in orbit. Photo credit: NASA/David Scott





Sparkling at the center of this beautiful NASA/ESA Hubble Space Telescope image is a Wolf-Rayet star known as WR 31a, about 30,000 light-years away in the constellation of Carina (The Keel).

Photo credit: ESA/Hubble & NASA, Acknowledgement: Judy Schmidt

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