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National Aeronautics and
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KENNEDY SPACE CENTER'S

SPACEPORT magazine

PREP FOR FLIGHT

Astronauts test Boeing's next gen spaceflight simulators

Aeronautics Research | Mars | Technology | Earth Right Now | ISS | Solar System & Beyond

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SPACEPORT MAGAZINE

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Front Cover: Commercial Crew astronaut Eric Boe practices docking operations for Boeing's CST-100 Starliner using a part-task trainer designed to mimic the controls and behavior of the spacecraft April 26. They are part of a suite of cloud-based and hands-on trainers that Boeing has built to prepare astronauts and mission controllers. The trainers will be shipped to NASA's Johnson Space Center in Houston this year so astronauts can use them daily to practice numerous situations from normal operations to unlikely emergencies. Photo credit: NASA/Dmitri Gerondidakis

Back Cover: For the 26th birthday of NASA's Hubble Space Telescope, Hubble image of the Bubble Nebula, or NGC 7635, was chosen to mark the 26th anniversary of the launch of Hubble into Earth orbit by the STS-31 space shuttle crew on April 24, 1990. Photo credit: NASA

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KSC BLOG

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NASA'S LAUNCH SCHEDULE

Date: June 18, 5:10 a.m. EDT
Mission: Undocking and Landing of Expedition 47 Crew
Description: Undocking of the Soyuz TMA-19M spacecraft from the Rassvet module and landing in Kazakhstan of the Expedition 47 crew.
http://go.nasa.gov/rpDbqR

Date: June 24, 2:41 a.m. EDT
Mission: Launch of Expedition 48 Crew
Description: Launch of the Expedition 48 crew on the Soyuz MS-01 spacecraft from the Baikonur Cosmodrome in Kazakhstan to the International Space Station.
http://go.nasa.gov/1VHuSAv

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/1ItsRkI

Date: Oct. 14
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

I am KENNEDY SPACE CENTER

TIM MOORE

I am the fire rescue/emergency management specialist in the Spaceport Integration Directorate's Protective Services Office at Kennedy Space Center. I wear many hats, such as ensuring that Kennedy's Fire Department is fully mission-capable to respond to any type of emergency.

I support SLS and Commercial Crew programs in developing plans for the rescue of astronauts from the launch pads.

I am thrilled to be a member of NASA Headquarters' Office of Protective Services Functional Review team. This offers me the opportunity to visit different NASA centers and evaluate their fire rescue response capabilities, and bring back best practices to Kennedy.

I also serve as the alternate NASA Emergency Management Office officer, or NEMO, where I am charged with coordinating and integrating all activities necessary to build, sustain, and improve Kennedy's capability to mitigate against, prepare for, respond to, and recover from natural disasters, acts of terrorism, or other man-made disasters.

I really can't say what the most exciting part of my job is because to me it is all exciting. When I know that my work will directly help someone who may be experiencing their darkest hour, I cannot help but feel fulfilled and excited about my career. I began working at Kennedy in 1986 for NASA's Return to Flight. I left twice but never found the NASA Kennedy esprit de corps of loyalty, teamwork, enthusiasm, and devotion to the mission anywhere else. When one has had the honor to be a member of Kennedy's team, it is hard to settle for anything less.

THRIVE AT FIVE

Concept's success buoys Commercial Crew's path to flight

BY STEVEN SICELOFF

Five years in, NASA's Commercial Crew Program is at the doorstep of launch for a new generation of spacecraft and launch vehicles that will take astronauts to the International Space Station, enhance microgravity research and open the windows to the dawn of a new era in human space transportation.

Returning the capability to launch astronauts from American soil brings tremendous satisfaction for the team working toward it.

"This is a new way of doing business, a new era in spaceflight, and when it's all said and done, the Commercial Crew Program's legacy will be bringing human spaceflight launches back to the U.S.," said Kelvin Manning, who was involved in the early planning days of the commercial crew effort, and is now associate director of Kennedy Space Center. "That's a big deal and our teams are making it happen."

Two aerospace companies are working toward the goal of flying in 2017, astronauts are training with state-of-the-art flight deck control systems and the space station is being prepped for the next human-rated spacecraft to arrive.

Launch pads on Florida's Space Coast are deep into modifications to meet the needs of astronauts and ground support staff. Manufacturing facilities for Boeing and SpaceX are working on prototypes of the spacecraft each company will use for NASA missions, then opening up the schedule for flights carrying private citizens.

As Boeing and SpaceX progress toward flight tests and operational missions for the Starliner and Crew Dragon, respectively, the space station team is already anticipating the added research a larger crew will enable on the orbiting laboratory.

"The new spacecraft will enable space station to operate at its full capacity for research," said Josie Burnett, who served as the deputy of the office that became the Commercial Crew Program and is now director of Exploration Research and Technology programs at Kennedy. "The limiting factor for station research is crew time, it's not cargo space or anything else."

The station's full complement would increase by one – from six

COMMERCIAL

CREW

in the making

NASA Missions

Integrated Systems

Systems

residents to seven –allowing another 40 hours a week for science on the station, meaning the crew's current research time allotment would double. That means double the amount of science that benefits people on Earth, as well as research to address the challenges of long-duration, deep-space missions on the journey to Mars.

The program's effect also is helping Kennedy evolve as a spaceport tailored to industry needs for a variety of rockets and spacecraft rather than a single mission. The benefit was not required, but a reflection of the unique possibilities at Kennedy, Manning said.

"Our assets and the availability of an experienced workforce made a strong business case to come here," Manning said. "As a result, with Boeing transforming Orbiter Processing Facility-3 into the manufacturing facility for the Starliner and SpaceX modifying Launch Complex 39A for Falcon rockets and Crew Dragons, they are key components in the creation of Kennedy's multi-user spaceport concept."

Business Unusual

This was the first time NASA asked industry to take the lead in designing, building and operating a space system that would carry astronauts. NASA offered its expertise in human spaceflight and wrote out the top-level requirements for safety and other considerations to prepare for flight tests. NASA will certify the vehicles for flight tests and finally operational missions. The companies apply their own knowledge and skills in designing, manufacturing and running the systems. Ultimately, NASA will buy the flights as a service from the companies.

"It's what we hoped the program to be and honestly a lot more," said Wayne Ordway, who began as the manager of the Commercial Crew Program's Spacecraft Office and rose to the position associate program manager.

This progress was hoped for, but took tremendous work and flexibility, according to members of the early efforts to transform the fledgling vision of a close partnership between NASA and private industry into a functioning organization capable of establishing requirements for a new generation of human-rated spacecraft and then seeing to it that those requirements were met.

"What's incredible about commercial crew is how dramatically we changed the strategy for human spaceflight access to low-Earth orbit," Ordway said. "We saw that industry was in a place where they could be a reliable service provider and integrator and we could allow market forces to bring us a more attractive solutions to our needs. It has come to fruition and is enabling us to put together one of the most cost-effective programs of its kind."

Those with the program knew they were being asked to conduct business in a non-traditional way.

"I think from a technical perspective, it really didn't appear to be that daunting of a problem, but from a cultural perspective, it appeared to be huge," said Donald Totton, deputy manager of the Spacecraft Office for commercial crew.

"I had a lot of optimism in what the program was doing," said Jon Cowart, a shuttle veteran whose first task in the Commercial Crew Program was drafting requirements for the new spacecraft and launch vehicles. "I knew the private sector had the ability to do a lot of this very rapidly. They were already being very innovative."

Collaboration with Industry

Based at NASA's Kennedy Space Center with significant operations at Johnson Space Center in Houston and Marshall Space Flight Center in Huntsville, Alabama, the commercial crew model tied together experts across the agency's field centers to establish requirements and approval methods through four progressively more complex development contracts.

"I am most impressed by the cross-agency team making it happen because what they are doing is very hard," said Manning. "Human spaceflight has never been easy, and consequently, developing a new space transportation system continues to be a complex process."

With a staff of about 300 — small for a human spaceflight development program — commercial crew relies heavily on specialized engineers across the nation to certify systems.

"We had to bridge across centers in a way that was really unique and the motivation was to be able to bring in the best talent in the agency wherever they were," Ordway said.

The Commercial Crew Program staff took several cues from success on commercial cargo. In 2008, NASA awarded contracts to SpaceX and Orbital ATK to resupply the space station with cargo

"What's incredible about commercial crew is how dramatically we changed the strategy for human spaceflight access to low-Earth orbit."

Wayne Ordway
Commercial Crew Associate Program Manager

launched from the United States. The companies developed the rockets and spacecraft through public-private partnerships under the agency's Commercial Orbital Transportation Services (COTS) program, an initiative that aimed to achieve safe, reliable and cost-effective commercial transportation to and from the space station and low-Earth orbit.

Eight companies played different parts in the Commercial Crew Program as Space Act Agreements began with broad concepts and subsystems that evolved into completed systems, spacecraft and launch vehicles that could meet the stringent demands of NASA's human-rating process. For example, spacecraft had to have built-in launch escape systems, and rockets built to fire satellites into orbit had to have room for myriad sensors that could report health factors in split-second intervals, all for costs much lower than previous development efforts for such spacecraft.

We wrote the requirements in such a way that our needs were met and that safety was a priority, but we didn't want to constrain the companies," Cowart said. "We really were looking to unleash the power of industry and innovation."

A precursor effort, known as Commercial Crew Development or CCDev, was started in 2010 with five industry partners. But, the Commercial Crew Program was formally established on April 5, 2011, marking five years this month. It took a total of five development and later certification phases to get to the point in September 2014 when NASA selected Boeing and SpaceX to build systems capable of carrying up to four astronauts plus time-critical cargo to the station. Starliner and Crew Dragon were chosen to begin manufacturing for flight tests and prepare for crew rotation missions.

"One of the biggest paradigm shifts for NASA in commercial crew is developing new human space transportation systems under a fixed-price model," Manning said. "This has never been done before for a program of this magnitude, moreover with two partners in parallel."

Each phase helped companies refine their systems as development advanced. Major systems such as avionics, parachutes and launch escape systems came first, then designs for complete rockets and spacecraft, then to the mission control systems the companies would use to oversee missions from the ground. Each phase also expanded the review scope and expertise needed for Commercial Crew Program staff that would certify that the requirements were met.

"The interesting thing that I think was really done well was that our technical requirements were known and remained at a high level," Totton said. "Our technical management process requirements were also at a high level and allowed significant flexibility to our providers to develop and operate these systems. We gave industry a lot of freedom while maintaining safety."

Totton says few requirements have changed as the systems and processes have matured, and he predicts the program will become a model for government giving industry the flexibility to develop a service.

"Eventually spaceflight will, I hope, be looked at as similar to the commercial airlines we fly on every day," he said.

Opposite top: The Commercial Crew Access Tower is viewed from the Vertical Integration Facility at Space Launch Complex 41 on Cape Canaveral Air Force Station in Florida. Photo credit: NASA/Cory Huston

Opposite bottom: Launch Pad 39A at Kennedy Space Center undergoes modifications by SpaceX to adapt it to the needs of the company's Falcon 9 and Falcon Heavy rockets, which are slated to lift off from the historic pad in the near future. A horizontal integration facility has been constructed near the perimeter of the pad where rockets will be processed for launch prior of rolling out to the top of the pad structure for liftoff. Photo credit: SpaceX

Above: Commercial Crew astronaut Eric Boe practices docking operations for Boeing's CST-100 Starliner using a part-task trainer designed to mimic the controls and behavior of the spacecraft. Working at Boeing's St. Louis facility, Boe and astronaut Suni Williams ran through numerous mission phases to assess the simulators before they are shipped to NASA's Johnson Space Center in Houston later this year. Photo credit: NASA/Dmitri Gerondidakis

Commercial Crew astronauts Doug Hurley, center, and Sunita "Suni" Williams sit inside a Crew Dragon mockup during an evaluation visit for the Crew Dragon spacecraft at SpaceX's Hawthorne, California, headquarters on Oct. 28, 2015. Photo credit: SpaceX

Learn more about Astronaut training by viewing the link below:
https://youtu.be/ulsn-EGs1p4

NEXT GEN

Simulators give astronauts glimpse of future flights

A training engineer watches at one station while Commercial Crew astronaut Suni Williams practices docking operations for Boeing's CST-100 Starliner using a part-task trainer designed to mimic the controls and behavior of the spacecraft. They are part of a suite of cloud-based and hands-on trainers that Boeing has built to prepare astronauts and mission controllers. Photo credit: NASA/Dimitri Gerondidakis

NASA's commercial crew astronauts Suni Williams and Eric Boe tried out a new generation of training simulators at the Boeing facility in St. Louis Tuesday that will prepare them for launch, flight and returns aboard the company's CST-100 Starliner spacecraft. The training also brought recollections of earlier eras when NASA's Mercury and Gemini spacecraft were built in St. Louis and astronauts routinely travelled to the city for simulator time.

NASA selected Bob Behnken, Doug Hurley, Boe and Williams in July to train for test flights aboard the Starliner and SpaceX Crew Dragon to the International Space Station. The flight assignments have not been set, so all four of the astronauts are rehearsing for the Starliner and Crew Dragon test flights to the space station.

The part-task trainers, each large enough for one person at the controls and programmed to run through all the phases of a mission, are part of a suite of cloud-based and hands-on trainers that Boeing has built to prepare astronauts and mission controllers. The trainers will be shipped to NASA's Johnson Space Center in Houston this year so astronauts can use them daily to practice numerous situations from normal operations to unlikely emergencies.

Astronauts typically spend hours training in simulators for every minute they fly in space so they are familiar with planned activities and can react quickly to unusual events. They rehearse their own decisions, as well as learn the teamwork vital to successfully overcoming a hurdle.

"These simulators have touchscreen displays, which means they are more versatile than previous spacecraft trainers," said Williams. "We

"We are at a point where we are actually training astronauts. Bringing that expertise and melding it into these trainers has been an honor and an extraordinarily cool experience."

–Pete Meisinger
Program Manager for Boeing's Space Vehicle Training Program

Commercial Crew astronaut Suni Williams practices docking operations for Boeing's CST-100 Starliner using a simulator designed to mimic the controls and behavior of the spacecraft. The Starliner is one of two spacecraft in development in partnership with NASA's Commercial Crew Program that will enable astronauts to fly to the International Space Station on a new generation of spacecraft made in America and launching from Florida's Space Coast. Working at Boeing's St. Louis facility, Williams and astronaut Eric Boe ran through numerous mission phases to assess the machines — called part-task trainers — before they are shipped to NASA's Johnson Space Center in Houston later this year. Photo credit: NASA/Dimitri Gerondidakis

can run multiple simulations by just changing software and then put that same software into a bigger crew simulator, which we will use to train the whole crew for a spaceflight."

When wired into the extensive Boeing and NASA networks, the simulators will interact with launch and mission controllers to run rehearsals that are critical to preparing a crew to successfully fly a mission and recover from unforeseen events.

Later, a simulator the size of a Starliner flight deck will be finished and used in Houston to train the full-flight crew.

Chris Ferguson is a former space shuttle commander who is now deputy program manager and director of Crew and Mission Systems for Boeing's Commercial Crew Program building the Starliner. While in St. Louis, he also took part in the simulations with the two commercial crew astronauts.

"These Crew Part-Task Trainers form the foundational capability for the astronauts to interact with the Starliner," said Ferguson. "We'll continue to build on these training systems and the momentum leading to flight."

Simulators have long been a staple in astronaut training starting with those used by Mercury astronauts and advancing to the motion-based flight deck simulator shuttle astronauts spent hours inside working on launch and landing skills. The simulators for NASA's Mercury and Gemini astronauts were at Boeing's plant — then McDonnell Aircraft — in St. Louis and the crews routinely fine-tuned cockpit layouts and control stick mechanics by practicing with modifications in the simulators first. At the time, neither Kennedy Space Center, nor Johnson Space Center in Houston, had simulators.

A considerable part of what we do here in St. Louis has been centered around developing trainers," said Pete Meisinger, Program Manager for Boeing's Space Vehicle Training Program. "After three years of working with Boeing experts in Houston and Florida, and with our NASA teammates, we are at a point where we are actually training astronauts. Bringing that expertise and melding it into these trainers has been an honor and an extraordinarily cool experience."

The trainers used Tuesday were tailored to various aspects of the Starliner operations. Other simulators will be built to cover all the aspects of spaceflight, from boarding the spacecraft at the launch pad, to safely climbing out at the end of the mission. Just as it was for the flight portions of mission preparation, the goal is to prevent the astronauts from being surprised.

"The simulations are important for the flight tests, because this is the place to put it all together," Boe said. "Think of the part-task trainer as our training wheels. As we get more familiar with the systems, the training wheels will come off and we will start advancing to the next systems. Eventually, we will work with another crew member, then with the whole flight control team."

Cabbage Patch

NASA's Veg-03 seeds planted in first lady's White House garden

BY LINDA HERRIDGE

First lady Michelle Obama plants the same variety of lettuce that was grown on the International Space Station in the White House Kitchen Garden with students that have their own school garden programs on April 5, 2016, in Washington, D.C. Photo credit: NASA/Aubrey Gemignani

ISS

Space-age plant seeds prepared by research scientists at Kennedy Space Center were planted in first lady Michelle Obama's White House Kitchen Garden on April 5. The seeds are from the same lot of 'Tokyo Bekana' Chinese cabbage seeds for the Veg-03 plant experiment bound for the International Space Station aboard the SpaceX Dragon cargo craft this month during its eighth Commercial Resupply Services mission.

The Chinese cabbage and some red romaine lettuce seeds were prepared inside a laboratory at Kennedy Space Center's Space Station Processing Facility and shipped to the White House about a month ago.

The first lady, NASA Deputy Administrator Dava Newman, and astronaut Cady Coleman participated in the event. Brad Carpenter, chief scientist for Space Life and Physical Sciences at NASA and Gioia Massa, NASA Veg-03 science team lead at Kennedy, also helped plant the seedlings with the kids.

"As we advance further along our Journey to Mars and prepare to send astronauts on long-duration exploration missions, the ability to grow nutritious food in space holds tremendous promise," Deputy Administrator Newman said. "The students I met at the White House are part of the Mars Generation, and it was fantastic to talk to them and the first lady about the work NASA is doing to make sure that the astronauts who land on Mars in the 2030s are able to grow fresh, nutritious food."

Students from across the country took part. Students from Bancroft Elementary School, who participated in the ground breaking of the garden and the very first planting in 2009, joined the first lady and helped plant the cabbage seeds. Also participating were students from the Harriett Tubman Elementary School, who along with Bancroft students, regularly help in the garden. They also planted some 'Outredgeous' red romaine lettuce seeds identical to those delivered to the space station for Veg-01 in 2014.

"I am thrilled to have the opportunity to see the first lady's garden," said Massa. "It is an honor, and I am so happy to be able to represent the amazing Veggie team at this event."

Veg-03 will continue NASA's deep-space plant growth research to benefit the Earth and the agency's journey to Mars. The plants will be grown in the Veggie plant growth system aboard the space station. The low-power, simple gardening system enables space plant biology and food production.

"I'm excited to have these seeds growing in the White House garden as we watch the same seeds grow in space" said Trent Smith, NASA Veggie project manager at Kennedy.

Just as the White House vegetable garden helps to promote healthy food choices on Earth, the ability to grow crop plants on the space station will provide astronauts with the option to supplement their diets with fresh, nutritious food. Also, future long-duration missions into the solar system, and eventually to Mars, will require a fresh food supply to supplement crew diets.

The White House vegetable garden was created on the South Lawn in 2009 by the first lady to start a conversation about health and wellbeing. Since its inception, the garden has contained about 55 varieties of vegetables, including arugula, lettuce, spinach, peppers, kale and berries. Now the garden also will contain Chinese cabbage and red romaine lettuce, provided by NASA Kennedy Space Center's Exploration Research and Technology Program.

First lady Michelle Obama, holds up NASA Veggie stickers while posing with Brad Carpenter, NASA chief scientist, Space Life and Physical Sciences, left; NASA Deputy Administrator Dava Newman, second left; NASA astronaut Cady Coleman, second right; and Gioia Massa, science team lead, Veggie project, right; after planting the same variety of lettuce that was grown on the International Space Station in the White House Kitchen Garden on April 5 in Washington, D.C. Photo credit: NASA/Aubrey Gemignani

"I'm excited to have these seeds growing in the White House garden as we watch the same seeds grow in space."

–Trent Smith
NASA Veggie project manager at Kennedy

PILLOW TALK

Matthew Romeyn, a NASA Pathways intern from the University of Edinburgh in Scotland, uses a tweezer to pick up a lettuce seed inside the Veggie flight laboratory in the Space Station Processing Facility at Kennedy Space Center. Photo credit: NASA/Ben Smegelsky

Veg-03 plant pillows delivered to space station

Plant pillows containing 'Tokyo Bekana' Chinese cabbage seeds for NASA's third Veggie plant growth system experiment, Veg-03, were delivered aboard the SpaceX Dragon cargo craft during its eighth Commercial Resupply Services mission to the International Space Station on April 8. The plant pillows were prepared at Kennedy Space Center before their trip to the space station. Veg-03 will continue NASA's deep-space plant growth research to benefit the Earth and the agency's journey to Mars.

Veg-03 is a follow-on experiment to the Veg-01 experiment that launched in 2014 and contained 'Outredgeous' red romaine lettuce seeds. Plants grow differently in space than on Earth based on differences in the environmental factors controlling growth. Future long-duration missions into the solar system, finally culminating on Mars, will require a fresh food supply to supplement crew diets. Understanding how plants respond to microgravity is an important step toward that goal.

"This variety of Chinese cabbage was selected based on excellent growth and flavor," said Gioia Massa, NASA Veg-03 science team lead. "Veg-03 will allow us to test a new variety of crop plants that we hope the crew will eat and enjoy as we work toward developing a salad system for ISS."

Inside a laboratory at the Space Station Processing Facility, the Veg-03 science team, including Massa, NASA postdoctoral fellow Dr. Matthew Mickens, and Matthew Romeyn, a NASA Pathways intern from the University of Edinburgh in Scotland, inserted a wick into each of the 18 pillows and then measured a precise amount of calcined clay, or space dirt, and fertilizer, and inserted the mixture into each pillow. Each plant pillow was sealed by sewing the open end shut.

The science team sanitized the cabbage seeds, along with

Matthew Romeyn, a NASA Pathways intern from the University of Edinburgh in Scotland, uses a tweezer to insert a 'Tokyo Bekana' Chinese cabbage seed into the wick of one of the plant pillows for the Veg-03 experiment inside the Veggie flight laboratory in the Space Station Processing Facility at Kennedy Space Center. The plant pillows was delivered to the International Space Station aboard the SpaceX Dragon cargo craft during its eighth Commercial Resupply Services mission. The Veg-03 plant pillows contain 'Tokyo Bekana' cabbage seeds and lettuce seeds for NASA's third Veggie plant growth system experiment. The experiment will continue NASA's deep space plant growth research to benefit the Earth and the agency's journey to Mars. Photo credit: NASA/Ben Smegelsky

additional 'Outredgeous' lettuce seeds, and then planted two seeds into each of the wicks before sealing the pillows in gas-impermeable bags and transferring them to the Engineering Services contractor for packing into a cargo transport bag. Twelve pillows of Chinese cabbage and six of lettuce were sent to the space station.

"This has been an amazing opportunity," Romeyn said. "I've enjoyed working at Kennedy Space Center. Everyone is smart and enthusiastic."

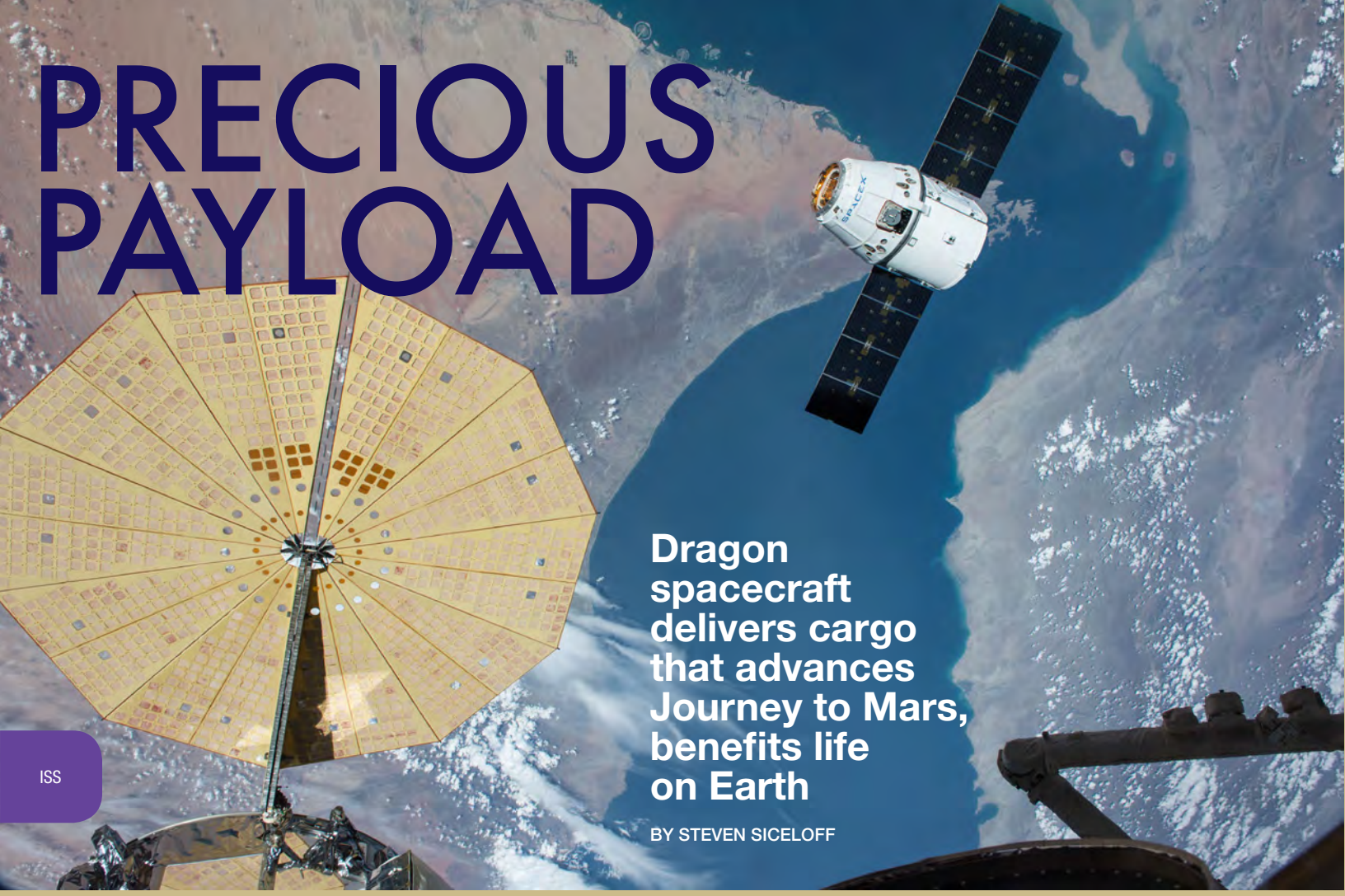
"Veg-03 will build on former crewmember Scott Kelly's autonomous gardening by testing similar gardening procedures with the leafy greens. We are hopeful that the station crewmembers will like the Chinese cabbage," said Trent Smith, Veggie project manager.

Aboard the space station, crew members will insert the plant pillows into the Veggie plant growth system, activate the system's LED lights, add water, and regularly monitor and care for the growth of the plants.

An identical ground control set of pillows were created and will be activated in the Veggie ground control unit in a controlled-environment chamber in the SSPF when Veg-03 is activated on the station.

Later this summer, NASA also will send a plaque to the International Space Station that the crew members will affix to the Veggie facility to recognize and honor the legacy of space biology pioneers, particularly the recently deceased Thora Halstead and Ken Souza. Their research exploring how living organisms respond to a low-gravity environment and their early stewardship of a new science that became the discipline of space biology will continue to benefit future explorers on the journey to Mars.

PRECIOUS PAYLOAD



ISS

Dragon spacecraft delivers cargo that advances Journey to Mars, benefits life on Earth

BY STEVEN SICELOFF

A SpaceX Falcon 9 rocket lifted off from Cape Canaveral Air Force Station in Florida on April 8 carrying a Dragon capsule loaded with 7,000 pounds of cargo, including scientific gear, crew supplies and an expandable module demonstration to deliver to the International Space Station as NASA continues research in the proving ground of space ahead of a future journey to Mars.

From genetics and biology to plant growth and engineering, the payloads aboard the Dragon showcase the diverse research fields NASA is covering in Earth orbit at the station to set a course for astronauts as they traverse millions of miles through space during future missions.

"This mission is an amazing bonanza for the biological sciences," said Kirt Costello, deputy chief scientist for the space station program.

The brilliant launch etched a yellow streak through the sky beginning at Space Launch Complex 40, a launch pad only a couple of miles from the processing hall where engineers from NASA and Lockheed Martin are assembling the Orion spacecraft that will fly atop the Space Launch System rocket to send astronauts into deep space.

Ahead of the launch, NASA and industry provided updates on the Orion spacecraft and innovations in development at Kennedy, including ground systems, for future deep space missions. The Orion pressure vessel is being assembled into a fully functional spacecraft as it sits inside a work stand in the high bay of the Neil Armstrong Operations and Checkout Building, the same area where Apollo command modules and lunar modules were readied for their missions.

The spacecraft is much larger than previous capsule designs and featured numerous state-of-the-art avionics systems and technologies aimed at keeping astronauts safe during flights in deep space, said Scott Wilson, NASA's Orion production manager.

Across the street from the Orion assembly area, scientists in the Swamp Works lab at Kennedy detailed the development of robots that could be tasked in the future with surveying asteroids up-close, digging up soils on other worlds to make fuel and air or conducting random searches in a group to gather resources on their own.

Much of the research on Earth is performed with an eye toward testing machinery and techniques in Earth orbit before committing to use them on missions far from the home planet.

For example, the scientists behind the Veggie experiments that already produced lettuce good enough to eat in space continue to advance up the vegetable chain to see what it will take to ultimately grow a space-borne garden of items like tomatoes, radishes and nutrient-rich versions of lettuce and cabbage.

Before astronauts can grow vegetables on the way to Mars, though, the team needs to see what grows best in space and refine the steps needed for success. That's where the space station comes in.

Packed inside the cargo bags on Dragon are pillow-shaped pouches loaded with seeds for Chinese cabbage along with a nutrient-rich material. The astronauts will load the pouches into specially designed trays that will give the plants the right amount of light to grow.

"There were a few things we needed to solve along the way as we grow these plants," said Gioia Massa, the researcher leading the Veg-03 experiment that launched aboard the Dragon.

By working on the orbiting laboratory in a variety of areas, astronauts can help researchers decipher some of the challenges of deep space missions while operating near Earth. As Boeing and SpaceX progress toward flight tests and operational missions with NASA's Commercial Crew Program, the space station team is anticipating the added research larger crews will enable on the orbiting laboratory to understand and address the challenges of long-duration spaceflight.

Once crews begin missions beyond Earth orbit in the 2020s and to Mars in the 2030s, they will need additional room to live and work. That is why the BEAM payload, short for Bigelow Expandable Activity Module, has captured the imagination of many in the space community, including engineers who hope it can serve as prototype for a large habitat or independent spacecraft in the future. The appeal of the design is that it can be packed to a size small enough to fit on a rocket, but expands once in space to offer astronauts a much bigger area to live and work inside during long-duration missions. BEAM is about 6 feet tall packed inside the Dragon's trunk. Once connected to the station, it will expand to more than 13 feet in length and 10.5 feet in diameter.

"The spacefaring world has been looking at expandables for quite some time," said Kirk Shireman, manager of the International Space Station Program. "The question is, how can you package something in a small volume to get it on a rocket and get it through the atmosphere, and then expand it to a size where people can live and work. Expandables could be an answer to that problem."

The Dragon caught up with the space station in orbit on Sunday morning. The station's robotic arm pulled it close and locked it into position, marking the first time the SpaceX Dragon and Orbital ATK Cygnus commercial cargo craft have been at the station at the same time. With six vehicles now docked with the station, the Dragon's arrival also ties the record for the most vehicles at the station at once.

"With the research that we do on station, it's critical that we have a constant supply chain coming up and coming back down," said Shireman. "We're looking for this flight to really set the tone and get us back to flying at a regular pace."

"We're looking for this flight to really set the tone and get us back to flying at a regular pace."

–Kirk Shireman
International Space Station Program Manager

A SpaceX Falcon 9 lifts off April 8 carrying a Dragon spacecraft to begin the CRS-8 mission delivering experiments and cargo to the International Space Station. Photo credit: NASA/ Tony Gray and Mike Kerley

Opposite: The SpaceX Dragon spacecraft nears the International Space Station during the CRS-8 mission to deliver experiments and supplies to the International Space Station. Photp credit: NASA

EARTH DAY

Astronaut photography from space helped 'Discover the Earth'

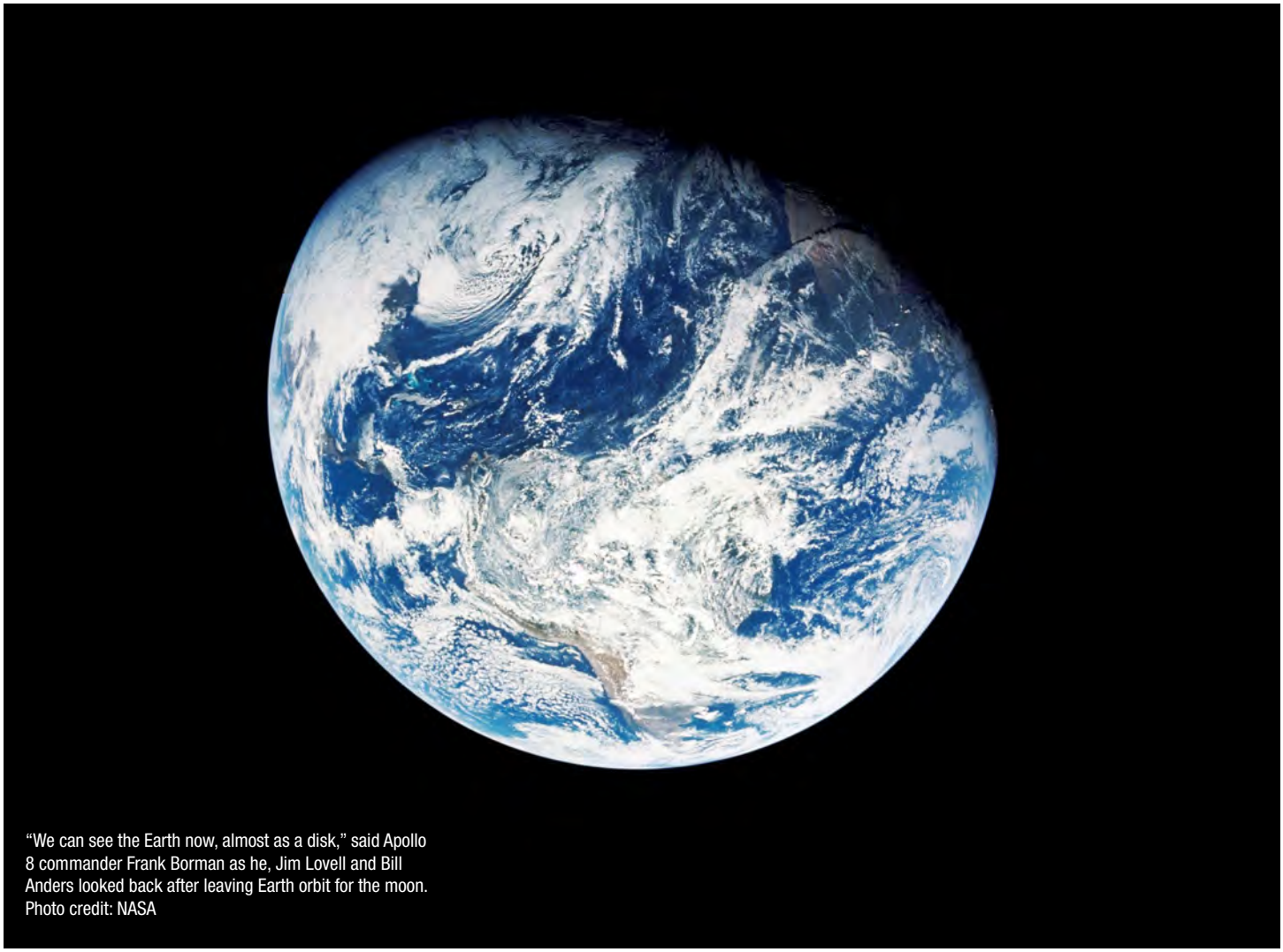
BY BOB GRANATH

A NASA scientific camera aboard the Deep Space Climate Observatory (DSCOVR) satellite returned this view of Earth on July 6, 2015, from a distance of one million miles. Photo credit: NASA

In December 1968, the crew of Apollo 8 became the first humans to leave Earth orbit and head for the moon. They also became the first to look back at their home planet and see the entire world in one glimpse. The view they shared had an everlasting impact.

Photographs of the Earth taken on the Apollo lunar voyages provided a view known as the "blue marble." One of the best-known NASA pictures is the image of the Earth rising above the desolate surface of the moon.

"It's the picture that was credited with starting the environmental movement," wrote author Jeffrey Kluger, referencing the Earthrise photo in a 2013 article for Time magazine.



"We can see the Earth now, almost as a disk," said Apollo 8 commander Frank Borman as he, Jim Lovell and Bill Anders looked back after leaving Earth orbit for the moon. Photo credit: NASA

In Life Magazine's "100 Photographs that Changed the World" edition published in 2003, renowned wilderness photographer Galen Rowell called the Earthrise photo, "the most influential environmental photograph ever taken."

The impact of seeing the world from the vantage point of a lunar mission was best summed up by Apollo 8 astronaut Bill Anders.

"We came all this way to explore the moon, and the most important thing is that we discovered the Earth," he said.

One result of the increased environmental awareness provide by the pictures of Earth taken on the nine Apollo missions to the moon was the establishment of Earth Day.

Earth Day was founded as an annual event less than two years after Apollo 8. First celebrated on April 22, 1970, activities now take place around the world, including Kennedy Space Center. The focus is to demonstrate support for protecting the environment.

"Observing our home is at the core of NASA's mission, and it continues to be a dynamic and growing area of our activity," said NASA Administrator Charlie Bolden in an Earth Day message to agency employees and contractors in 2015. "We want to know how our planet works, how we affect it, and how it might change in the future."

According to Earth Day Network, the organization that coordinates the global event is designed to inspire, challenge and motivate people to action.

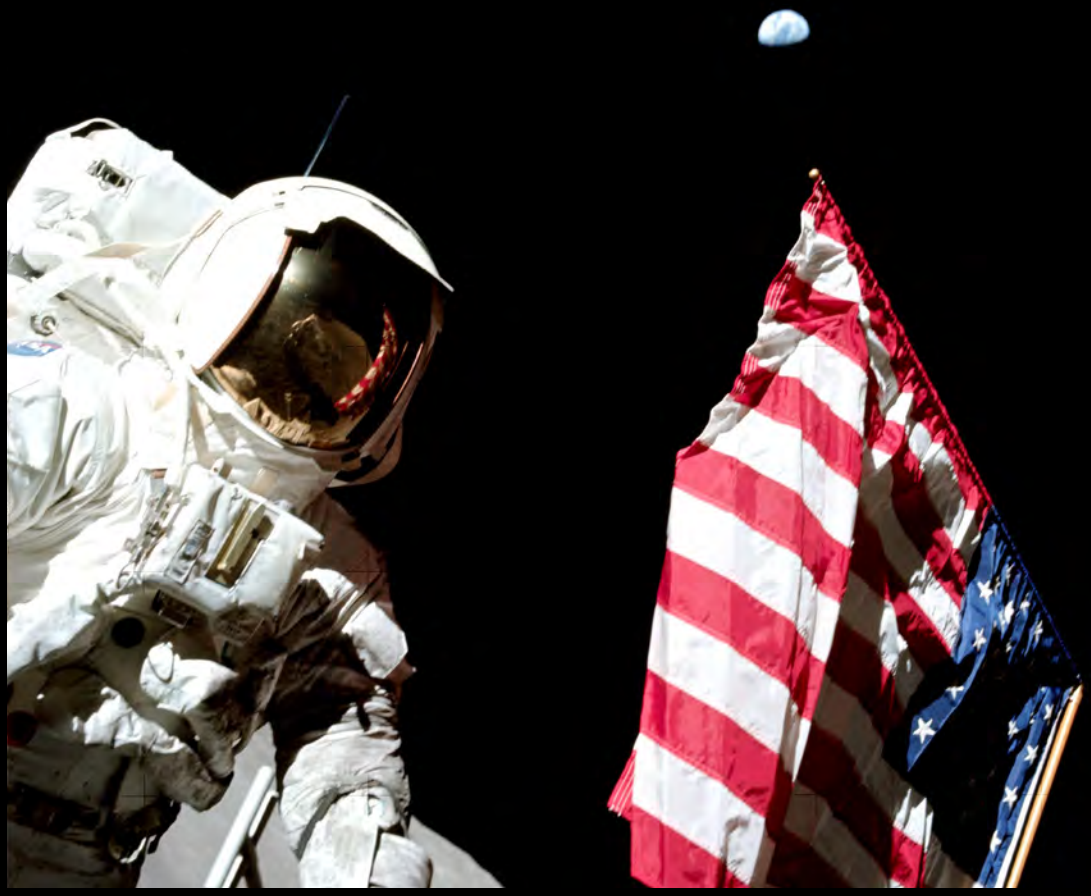
"In 1970, the year of our first Earth Day, the movement gave voice to an emerging consciousness, channeling human energy toward environmental issues," said the Earth Day Network website.

Since its inception in 1958, much of NASA's work has focused on studying Earth and better understanding weather, climate and

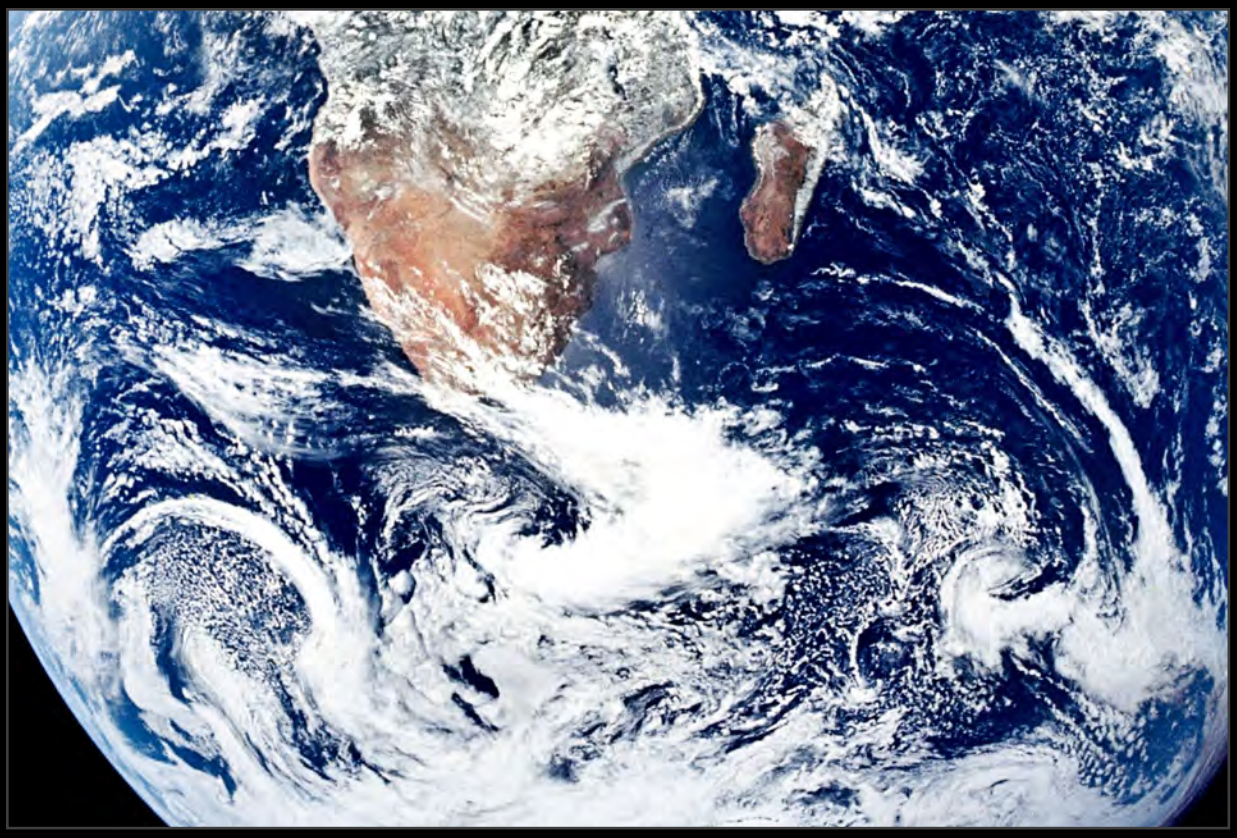
"We came all this way to explore the moon, and the most important thing is that we discovered the Earth."

– Bill Anders
Apollo 8 Astronaut

Contrasted against the stark, crater-marked lunar surface, the Earth is 240,000 miles away rising above the moon on Dec. 24, 1968.
Photo credit: NASA/Bill Anders



Apollo 17 lunar module pilot Harrison Schmitt is photographed next to the deployed United States flag with the tip pointing toward Earth. Photo credit: NASA/Eugene Cernan



This view of a portion of Earth was taken from the Apollo 17 shows the southern part of Africa with the island of Madagascar at right and Antarctica visible at the bottom. Photo credit: NASA

In this night image from Jan. 29, 2012, human presence is clearly visible as the space station passed over the Gulf of Mexico looking north to the southeastern United States.

"It's hard to get a sense that this planet is populated by humans, except at night. That's when all the cities come to life with lights that show up at night."

– Dan Burbank
Expeditions 29 and 30 Astronaut

Inside the International Space Station cupola, NASA astronaut Chris Cassidy, an Expedition 36 flight engineer, uses a 400 mm lens on a digital still camera to photograph the Earth some 240 miles below. Photo credit: NASA

The morning sun reflects on the Gulf of Mexico and the Atlantic Ocean as seen from the Apollo 7 spacecraft on Oct. 20, 1968. Photo credit: NASA

the forces that make a difference in people's lives around the world.

NASA's work in Earth science is making a difference in people's lives around the world every day. From farms to our national parks, from today's response to natural disasters to tomorrow's air quality, from the Arctic to the Amazon, NASA is working for you 24/7.

Satellites launched in recent years such as Landsat, Jason-3, the Deep Space Climate Observatory, Orbiting Carbon Observatory-2 and Soil Moisture Active Passive are aiding scientists in research, yielding extensive benefits. These include improved environmental forecasts, better understanding of natural hazards and helping researchers determine ways to enhance utilization of the Earth's resources.

But the view with human eyes remains priceless.

On Dec. 21, 1968, Anders along with Apollo 8 crewmates Frank Borman and Jim Lovell fired the upper stage of their Saturn V rocket, leaving Earth orbit on a trajectory to the moon. As they turned their Apollo command-service module around, the view was striking.

"We see the Earth now, almost as a disk," said Borman.

Lovell described the view to Mission Control.

"We have a beautiful view of Florida now," he said. "We can see the Cape (Canaveral), just the point. And at the same time, we can see Africa. West Africa is beautiful. I can also see Gibraltar at the same time I'm looking at Florida."

"Get a picture of it," said fellow astronaut and spacecraft communicator Mike Collins in Mission Control.

The pictures were as historic as they were stunning.

Three days after launch, Apollo 8 was completing 10 orbits of the moon. During a Christmas Eve television broadcast, Lovell noted the contrast between the stark, cratered lunar surface and the view of the 240,000-mile distant world.

Top to bottom:
Since November 2000, the International Space Station has been permanently staffed, circling the Earth every 90 minutes. Photo credit: NASA

India and, on the right, the island of Ceylon (now Sri Lanka) as seen from the Gemini XI spacecraft at an altitude of 410 miles on Sept. 14, 1966. Photo credit: NASA

One of the Expedition 36 crew members recorded this view of the massive drought-aided Rim Fire in and around California's Yosemite National Park and the Stanislaus National Forest on Aug. 26, 2013. Photo credit: NASA

On March 29, 2014, Expedition 39 crew members used a digital still camera to photograph this pre-winter storm located just off the coast of southwestern Australia. Photo credit: NASA

Photo credit: NASA

"The vast loneliness up here of the moon is awe-inspiring," he said, "It makes you realize just what you have back there on Earth. The Earth from here is a grand oasis in the big vastness of space."

Now that the International Space Station has been permanently staffed since November 2000, Earth photography has been an important objective.

"The view from the station is absolutely breathtaking," said Expeditions 29 and 30 astronaut Dan Burbank when he returned to Kennedy and spoke to employees on June 7, 2013. "We have some impressive cameras on the space station. The vantage point of seeing this incredible planet from 240 miles above is just unbelievable."

While showing daytime photographs of Earth, Burbank noted that there are striking differences between daylight and night images of the planet.

"It's hard to get a sense that this planet is populated by humans, except at night," he said. "That's when all the cities come to life with lights that show up at night."

ISS Expedition 26 and 27 astronaut Cady Coleman spoke to Kennedy employees on Sept. 20, 2012. She explained that the view out the window gives a different perspective on life below.

"When you see our whole planet like this," she said, "you realize we are altogether citizens of the world."

Astronaut Ron Garan expressed similar beliefs when he spoke at Kennedy on Aug. 8, 2012, following ISS Expeditions 27 and 28. He noted the need to care for Earth.

"When you see the beauty of our planet, it is striking, it's sobering," Garan said. "For the 50 years that we've been flying humans in space, astronauts and cosmonauts have always commented about how beautiful, how fragile and how peaceful our planet looks from space. Seeing this from space really had a big impact on me."

The northern tip of Cape Cod, Massachusetts is seen in this 8.5 mile section of its 65-mile length. Many ponds are seen in the center of the image. Photo credit: NASA

Photo credit: NASA

Top to bottom:
On May 23, 2006, Expedition 13 astronaut Jeff Williams photographed the Cleveland Volcano producing a plume of ash. Photo credit: NASA/Jeff Williams

As NASA astronaut Scott Kelly completed a year in Earth orbit aboard the International Space Station, he looked down at the Kennedy Space Center, on Feb. 28, 2016. Photo credit: NASA/Scott Kelly

Expedition 46 flight engineer Tim Peake of the European Space Agency shared a stunning image of a glowing aurora taken on Feb. 23, 2016. Photo credit: ESA/NASA


EAR
RIGHT
YOUR PLANET IS CHANG


RTH
NOW
#24SEVEN
GING. WE'RE ON IT!

EARTH DAY 2016

Earth Right Now

Sustainability takes center stage during activities

There's no place like home. That was the prevailing attitude at Kennedy Space Center on April 21-22 as the spaceport marked the 46th annual Earth Day with a two-day celebration designed to spread awareness of our planet's needs — and to share innovations that can contribute to sustainable living both at work and at home.

For more than four decades, NASA has been using the vantage point of space to increase our understanding of Earth and safeguard our future while improving lives.

"At NASA, it's Earth Day every day as 20 missions continuously orbit the planet to study climate change, the behavior of oceans, precipitation worldwide, and many other Earth vital signs that help us become better stewards of our home," NASA Administrator Charles Bolden said in an Earth Day statement to employees.

This year's Earth Day expo showcased demonstrations and products by exhibitors from across the country in order to get people thinking about changes they can make in order to preserve our planet and its limited resources.

The event kicked off in Kennedy's Space Station Processing Facility on April 21, then moved to the Kennedy Space Center Visitor

A young visitor to the Kennedy Space Center Visitor Complex helps a newly released butterfly prepare for its first flight during an Earth Day celebration on April 22. Small groups of butterflies native to Florida were released throughout the day in the complex's Rocket Garden with the assistance of visitors and event personnel. Some of the colorful insects flew quickly and confidently above the crowd, while others rested on the fingers of their human helpers, beating their wings until they were ready for takeoff. Photo credit: NASA/Glenn Benson

Opposite: A newly released white peacock butterfly rests on a plant at the Kennedy Space Center Visitor Complex Rocket Garden, where butterflies native to Florida were released throughout the day. NASA's Kennedy Space Center in Florida marked the 46th annual Earth Day on April 21-22 with a two-day celebration designed to spread awareness of our planet's needs – and to share innovations that can contribute to sustainable living both at work and at home. Photo credit: NASA/Glenn Benson

Complex on April 22, allowing employees and visitors to learn and benefit from the array of available activities.

More than a dozen electric cars were on display from a variety of automakers. Some were available for test drives, and many participants took advantage of the opportunity to try out the vehicles.

Several exhibitors shared technologies and tips for saving energy and water in the workplace, the home and throughout the community through water treatment, recycling and lighting controls, among others. Guests also had the opportunity to see a variety of green, biobased and recycled products, and learn about their origins and advantages.

Florida's natural environment also played a starring role, with wildlife and conservation specialists such as the Brevard Zoo and Merritt Island National Wildlife Refuge on hand to discuss methods to safeguard wildlife, preserve natural resources, and protect Florida waters.

NASA Biological Intern Taylor Pitcock of Kennedy's Environmental Management branch held an Eastern corn snake, allowing guests to see and touch the non-venomous reptile.

"It's always a good time to see kids' reactions, hear the questions they ask, and watch the excitement on their faces when they get to hold a snake," Pitcock said.

Master gardeners and pollinator specialists offered their expertise and answered questions, and native butterflies were released throughout the day at the visitor complex on Friday.

Visitors gathered in the complex's Rocket Garden to help open small envelopes to free the butterflies. Some of the creatures immediately fluttered above the crowd while others gingerly tested their wings before flying away.

NASA's sustainability policy is to execute NASA's mission without compromising our planet's resources so that future generations can meet their needs. Sustainability also involves taking action now to provide a future where the environment and living conditions are protected and improved.

"Every day is Earth Day," Pitcock said. "Everybody can do their own part. No action is too small."

ROCKETS AND REFUGE

Kennedy Space Center is on a barrier island, called Merritt Island, about 34 miles long and varying in width from five to 10 miles. The total land and water area covers slightly more than 140,000 acres, however, only 6,000 acres are used for space operations.

Kennedy shares borders with the Merritt Island National Wildlife Refuge, which is home to more than 330 native and migratory bird species, along with 25 mammal, 117 fish, and 65 amphibian and reptile species.

The refuge provides a wide variety of habitats that include coastal dunes, saltwater marshes, freshwater impoundments, scrub, pine flatwoods, and hardwood hammocks that provide habitat for more than 1,500 species of plants and animals and 15 federally listed species.

For more about wildlife and habitat at Kennedy Space Center, go to http://go.nasa.gov/1nlV5rR

A sandhill crane and its chicks search for bugs in the grass near the Kennedy Space Center Visitor Complex on April 20. Photo credit: NASA/Kim Shiflett

A pied-billed grebe paddles in one of the many waterways at Kennedy Space Center. Photo credit: NASA/Bill White

From its perch high up in a pine tree, a bald eagle keeps a watchful eye on its large nest, called an aerie. Photo credit: NASA/Bill White

Black skimmers take a break from flying on a riverbank.

Thistle blooms provide a midday meal for a gulf fritillary butterfly at Merritt Island National Wildlife Refuge. Photo credit: NASA/Bill White

WHAT'S IN YOUR TOOLBOX

Custom equipment required to install work platforms in Vehicle Assembly Building

BY LINDA HERRIDGE

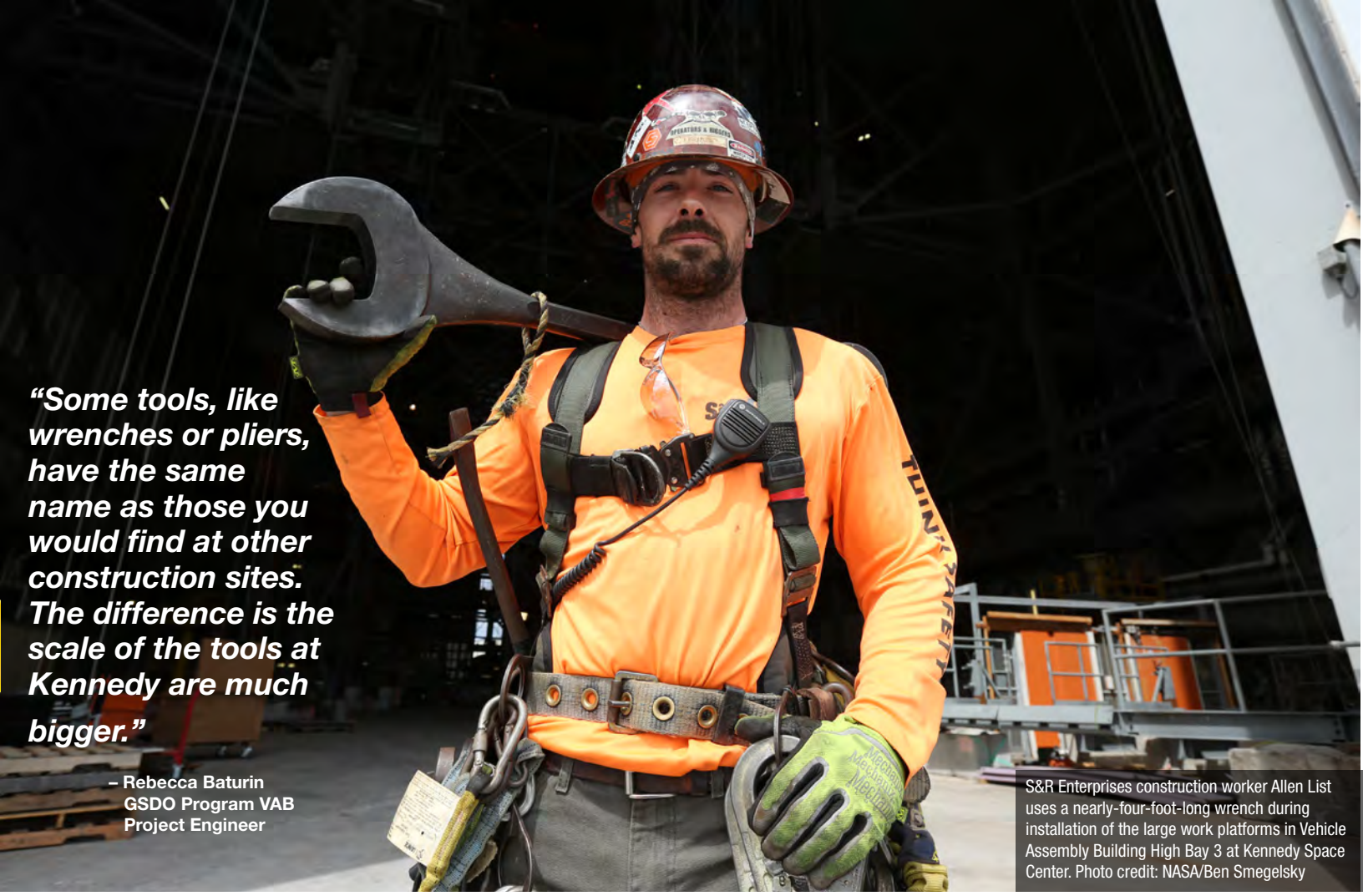
A spreader bar weighing thousands of pounds and a wrench that is nearly four feet long are not the usual type of equipment you would carry in a toolbox or store in your garage. But they are among the larger-than-life specialized tools that are used by technicians and construction workers at NASA's Kennedy Space Center in Florida to prepare and install the giant work platforms in the Vehicle Assembly Building (VAB) for the agency's Space Launch System (SLS) rocket and Orion spacecraft.

In High Bay 3 of the VAB, 10 levels of work platforms, 20 platform halves altogether, will surround the SLS rocket and Orion spacecraft and provide access to process and prepare them for launch to deep-space destinations, such as the journey to Mars. Two sets of work platforms, the K-level and J-level platforms, recently were installed in the high bay, about 86 feet and 112 feet above the VAB floor, respectively.

During one of the platform installations, Allen List, an iron and rig foreman with S&R Enterprises of Harrisburg, Pennsylvania, a subcontractor to VAB general contractor Hensel Phelps, handled the 50-pound, nearly four-foot-long wrench like a pro as he turned and tightened the large corbel pin locks, or rail bolts, that will keep the platform securely fastened to the structural steel of the high bay.

Along with the wrench, he also wore a tool belt that weighs about 45 to 50 pounds, plus the tether system that all of the construction workers are required to use when performing tasks above the ground level.

"This is a unique building, and the work we are doing requires



"Some tools, like wrenches or pliers, have the same name as those you would find at other construction sites. The difference is the scale of the tools at Kennedy are much bigger."

– Rebecca Baturin
GSDO Program VAB
Project Engineer

S&R Enterprises construction worker Allen List uses a nearly-four-foot-long wrench during installation of the large work platforms in Vehicle Assembly Building High Bay 3 at Kennedy Space Center. Photo credit: NASA/Ben Smegelsky

some unique tools," List said. "This wrench is very hard to use. It requires two hands to turn it to tighten bolts."

Tools such as the wrench and long pry bars were acquired from an industrial tool supplier, but Hensel Phelps and the architect of record, Reynolds, Smith and Hills, created several of the unusual tools specifically for the VAB work project.

"Some tools, like wrenches or pliers, have the same name as those you would find at other construction sites. The difference is the scale of the tools at Kennedy are much bigger," said Rebecca Baturin, VAB project engineer with the Ground Systems Development and Operations (GSDO) Program.

Another gigantic tool that definitely would not fit in your garage is the Tandemloc spreader bar. This bar is attached to the crane rigging to safely help lift the work platforms during installation. The spreader bar weighs 31,000 pounds, and is 50 feet long and 26 inches in diameter. Another set of Tandemloc bars are 25 feet long and 14 inches in diameter and are used as rigging, or support equipment, in conjunction with the main spreader bar for lifting the platforms in place.

A set of Corbel spreader beams, each weighing 11,000 pounds and measuring 70 feet long and 16 inches in diameter, are bolted directly to the front and rear of the platform halves to keep them level and aligned as they are lifted and installed in the high bay. At the end of each Corbel spreader is a 50-ton portable hydraulic jack that can be used to adjust the alignment.

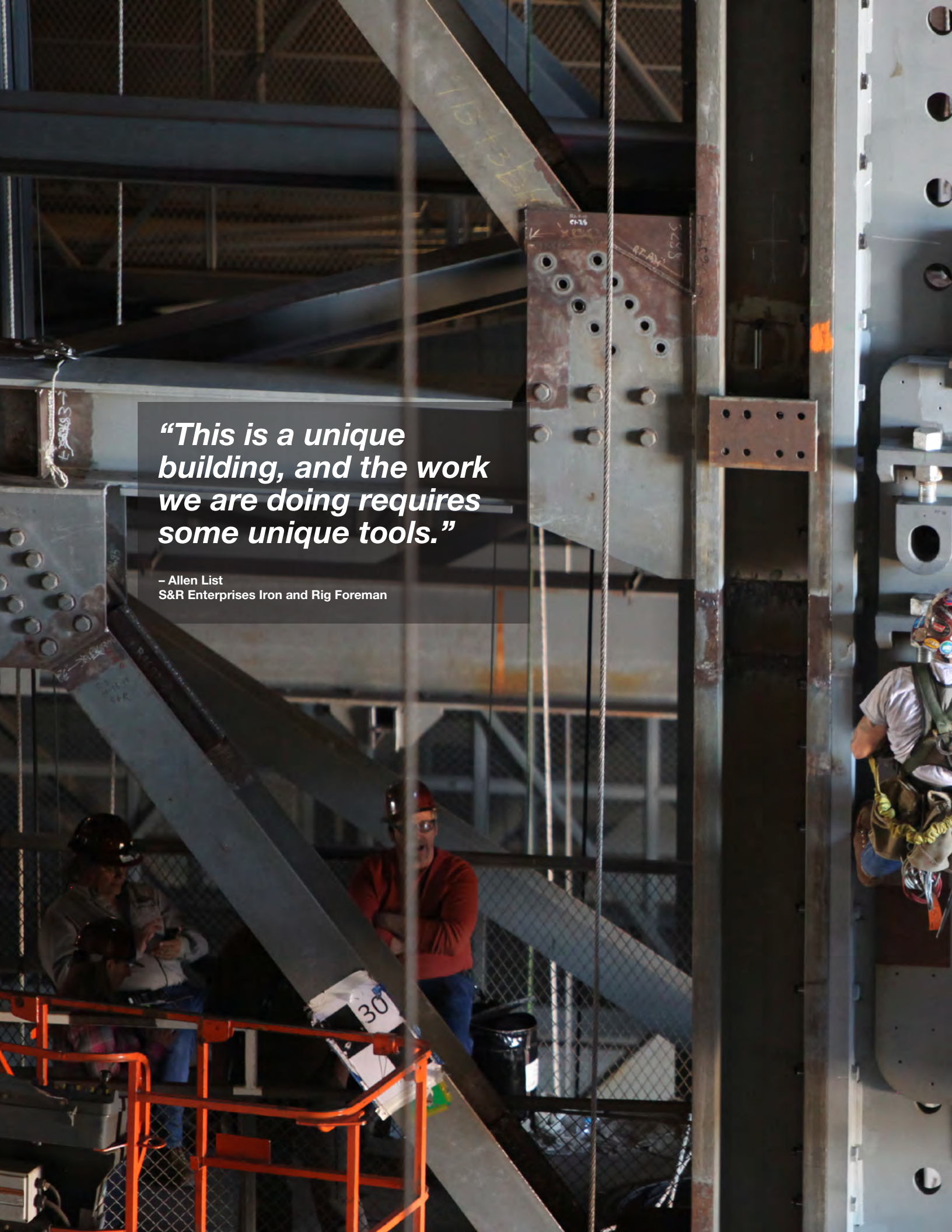
Tools called Hydra sets are a load positioning system that was used during the Space Shuttle Program for lifting flight hardware. The 31,000-pound tools are being repurposed because they provide precise vertical control of heavy loads in tight configurations, such as the large work platforms. During a platform lift, they are suspended between the crane rigging and the platform to enable each corner of the crane rigging to be independently adjusted to keep the platform level.

"It would not be possible to install the platform halves accurately without the Corbel spreader beams and Hydra Sets. It would not be possible to even lift a platform half without the crane rigging and Tandemloc bars," Baturin said.

Multi-wheeled, heavy-duty transporters, called Goldhofers, move the platform halves from the VAB west parking lot staging area into the VAB transfer aisle.

"It's an honor to help contribute to NASA's space program," List said. "Nowhere else in the country would we have the opportunity to contribute to something like the work we are doing in the Vehicle Assembly Building. This is a very exciting time."

Whether it is with a 4-foot wrench or a 15-ton spreader bar, Kennedy Space Center is well on its way to preparing the VAB High Bay 3 for the SLS rocket and Orion spacecraft and the agency's journey to Mars.



“This is a unique building, and the work we are doing requires some unique tools.”

– Allen List
S&R Enterprises Iron and Rig Foreman

Construction workers install a work platform March 8 in the Vehicle Assembly at Kennedy Space Center.
Photo credit: NASA/Dimitri Gerondidakis

To watch the wrench in action, go to
https://youtu.be/YYgXNT6QCEw

"We are now a true multi-user spaceport supporting a variety of different partners successfully."

–Bob Cabana
Kennedy Space Center Director

NASA has selected Orbital ATK Inc. of Dulles, Virginia, to begin negotiations on an agreement to use High Bay 2 in the iconic Vehicle Assembly Building, or VAB, at Kennedy Space Center.

The prospective property use agreement, which also will include a mobile launcher platform, reflects Kennedy's transformation to a multi-user spaceport supporting both government and commercial organizations.

"Over the past few years, the people of Kennedy have worked diligently to transform the center. We are now a true multi-user spaceport supporting a variety of different partners successfully," said Bob Cabana, Kennedy director. "We look forward to working with Orbital ATK in the future to help expand the capabilities of this unique, historic asset."

NASA will remain the primary user of the VAB for the Space Launch System and Orion programs. If an agreement is negotiated, NASA will act as the overall site operator for the facility.

The potential agreement is the result of a competitive Announcement for Proposals the agency released in June 2015.

The VAB, a national landmark, was completed in 1966 for the assembly of the Apollo/Saturn V moon rockets. For 30 years, it acted as the final assembly point for all space shuttle missions. The building is 525 feet tall and 518 feet wide.

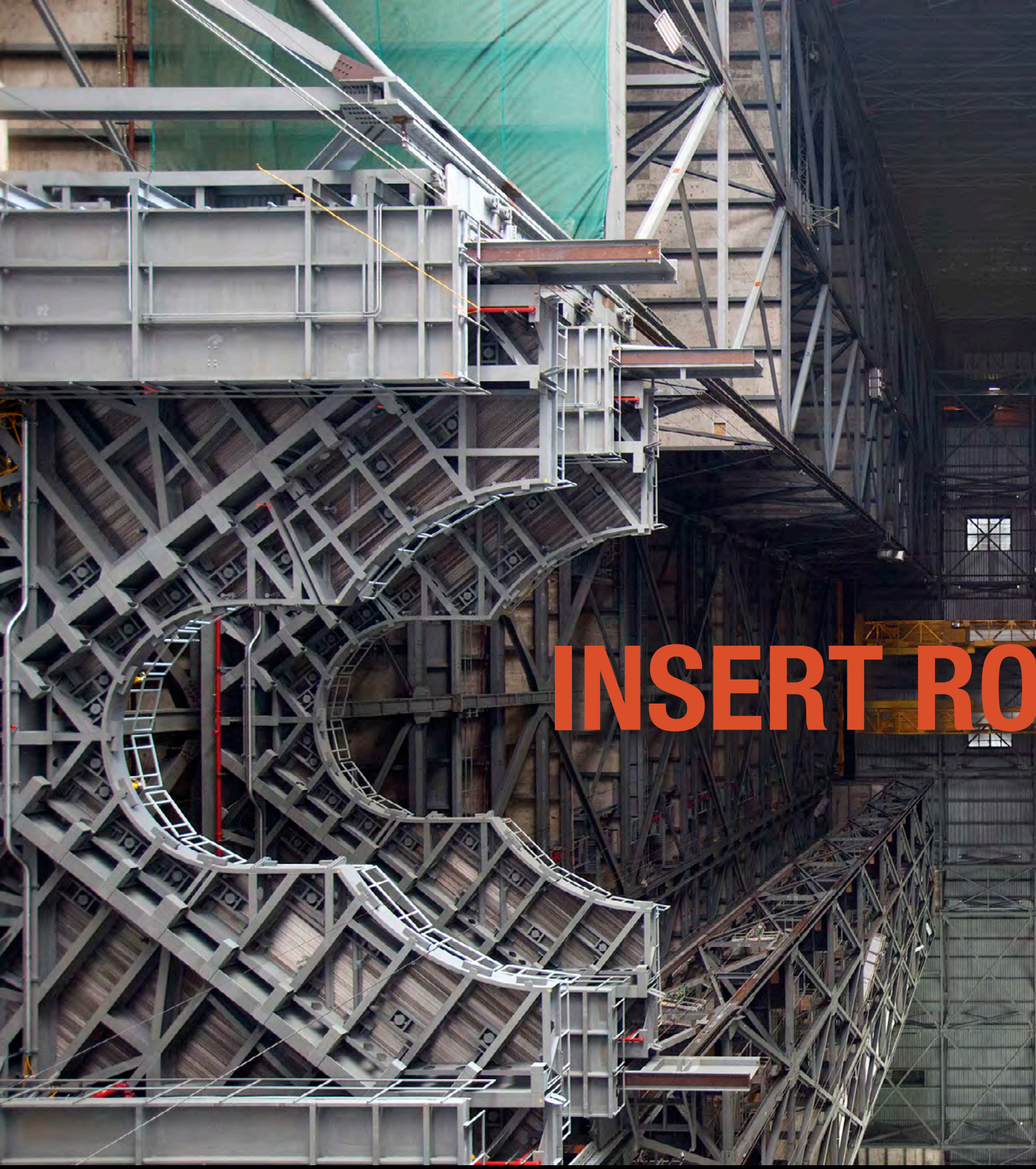
Essentially a large steel box, a mobile launcher platform measures 160 by 135 feet. The platform's surface features wide openings that align with a space-bound vehicle's engines and direct the rocket's blast into the flame trench below.

For more information about partnership opportunities with Kennedy, visit: http://kscpartnerships.ksc.nasa.gov

For more information about Orbital ATK, visit: https://www.orbitalatk.com

For more information on NASA and agency programs, visit: http://www.nasa.gov

Opposite: NASA has selected Orbital ATK, to begin negotiations on an agreement to use High Bay 2, in the iconic Vehicle Assembly Building (VAB) at Kennedy Space Center. The prospective property use agreement reflects Kennedy's transformation to a multi-user spaceport supporting both government and commercial organizations. The agreement also includes a space shuttle-era mobile launcher platform. NASA will remain the primary user of the VAB for the Space Launch System and Orion programs. The potential agreement is the result of a competitive Announcement for Proposals the agency released in June 2015. Photo credit: NASA/Kim Shiflett



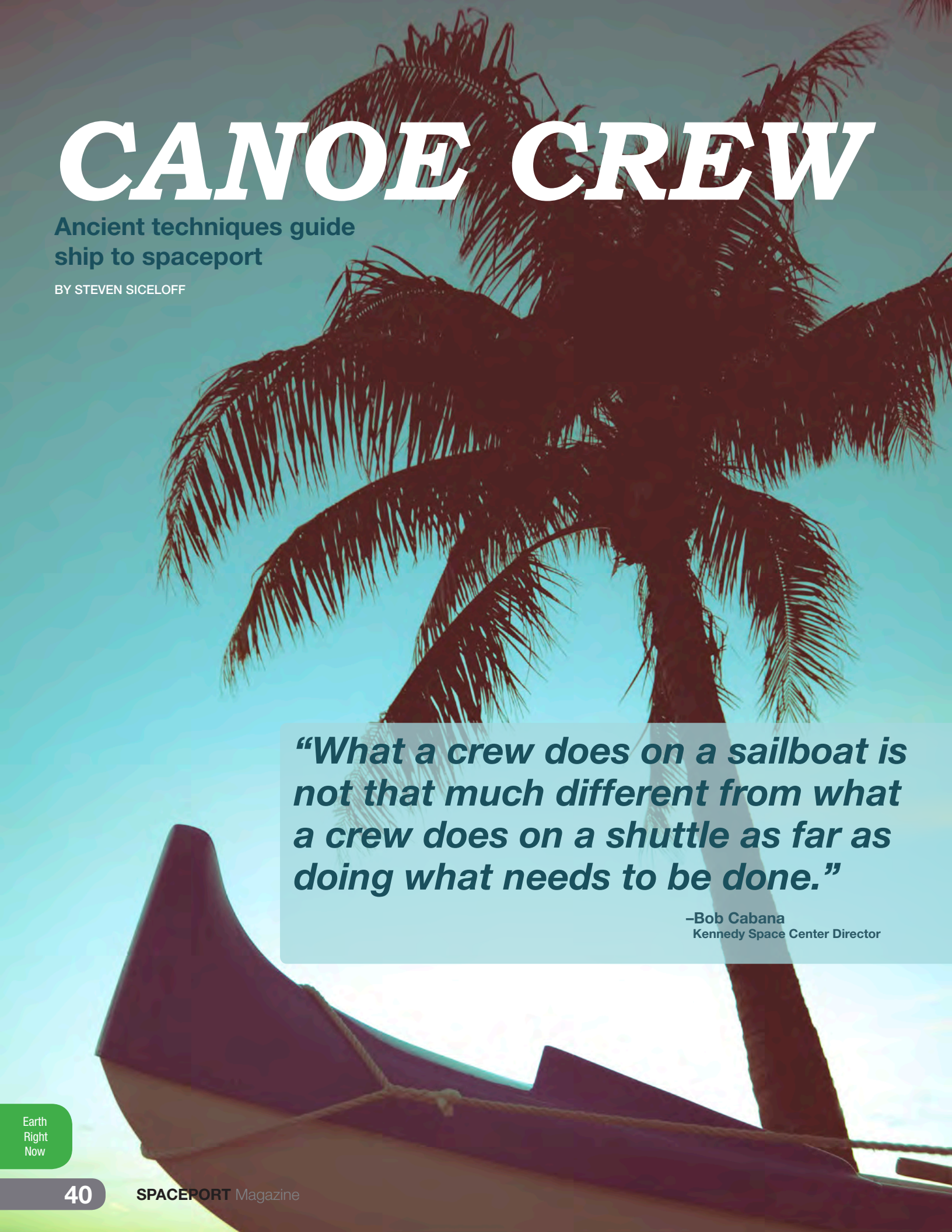
A view from below in High Bay 3 inside the Vehicle Assembly Building at NASA's Kennedy Space Center, shows three work platforms installed for NASA's Space Launch System (SLS) rocket. The lower platforms are the K-level work platforms. Above them are the J-level work platforms. A crane is lowering the second half of the J-level platforms April 15 for installation about 112 feet above the floor, or nearly 11 stories high. The newly installed platform completes the second of 10 levels of work platforms that will surround and provide access to the SLS rocket and Orion spacecraft for Exploration Mission 1. The Ground Systems Development and Operations Program is overseeing upgrades and modifications to VAB High Bay 3, including installation of the new work platforms, to prepare for NASA's journey to Mars. Photo credit: NASA/Dimitri Gerondidakis

JOURNEY TO MARS

CANOE CREW

Ancient techniques guide ship to spaceport

BY STEVEN SICELOFF



"What a crew does on a sailboat is not that much different from what a crew does on a shuttle as far as doing what needs to be done."

–Bob Cabana
Kennedy Space Center Director

Steering cutting-edge spacecraft above the planet and through space on natural forces is not that different from guiding a ship of ancient design over the oceans and seas on the Earth, sailors from the Polynesian Voyaging Society and Kennedy Space Center director Bob Cabana agreed during a ceremony near the Florida spaceport.

"We sail on a giant space of ocean and they fly in a giant ocean of space," said Nainoa Thompson, captain of the Hakulea, a traditional Hawaiian double-hulled oceangoing canoe strong enough to carry its crew on a trip around the world. "We sail on this ancient vessel of our ancestors from two to three thousand years ago, and today we get to see the ships of our children. I humbly would say that there are parallels when you look at the power of exploration and power of discovery."

Cabana, a veteran of four space shuttle missions including the first to assemble the International Space Station, said astronauts have to work closely and as a dedicated team to have the same success traveling through space as the crews sailing on a ship.

"What a crew does on a sailboat is not that much different from what a crew does on a shuttle as far as doing what needs to be done," Cabana said.

For master navigator Bruce Blankenfield, the key is carefully reading all the signs around the boat to figure out the best path. The waves, wind, sun and stars all offer crucial signs around the clock to show the crew where they are and where they are going. Blankenfield made his first trip in 1977 on the same vessel that docked near Kennedy.

The traditionally designed, ocean-going Hawaiian canoe Hokulea transits the Indian River as it makes its way to the Titusville Marina near Kennedy Space Center. The crew of the vessel are sailing the ship around the world demonstrating ancient navigation techniques and to raise awareness of climate change issues. The crew later toured Kennedy and paid tribute to Hawaiian-born astronauts Lacy Veach and Ellison Onizuka. Photo credit: NASA/Frankie Martin

Thompson and a crew of 14 are sailing the 62-foot-long, 20-foot-wide, catamaran-style vessel around the world to teach the art and science of navigating the seas in the same manner used 2,000 years ago by Polynesian sailors. They do not use western instruments during long stretches of the trip, but have them onboard in case of safety needs.

The trip started in Hawaii in 2014 and has stopped in Australia, India, South Africa, Brazil and the Caribbean before going back to Hawaii. The crew changes regularly to give people all over the world – usually teachers, educators and students — the chance to learn the skills and play a role in the overall voyage.

"At the Cook Islands several years ago, three of the shuttle astronauts came on board, and one of the things they were talking about was body vectors of the shuttle and the stars," Blankenfield said. "It's the same concept we use here. Keep the sun off your beam, and the astronauts said they did the same thing with the shuttle to keep the heading."

NASA's navigators have built up an enviable record of success steering rockets into precise corridors, then guiding spacecraft through intricate maneuvers that use as little fuel as possible but put the ships on course to reach distant worlds ranging from the moon and Mars to Jupiter and, in the case of New Horizons, Pluto.

The crew of the Hokulea and senior staff from Kennedy Space Center take part in a ceremony aboard the ship. Photo credit: NASA/Ben Smegelsky

While the Earthbound sailors use the winds and waves of this planet to give them an efficient route through the oceans, space travelers, whether human or machine, try to ride the natural strength of gravity wells to assist them.

"I have the highest respect and regard for the astronauts because I know it's dangerous," Thompson said, "but at the same time I know they are like us: the purposes that we sail and that they fly outweighs the risk. The other piece is that success is really determined by how well you prepare."

The stop in Titusville, which included a tour of the space center and a presentation to the Kennedy workforce, also focused on honoring the memories of two Hawaiian astronauts, Charles "Lacey" Veach and Ellison Onizuka. Both astronauts have passed away, but Thompson said their memories are held tight to inspire the team as they travel the world at a 4-knot pace.

"Today's the day to honor our Hawaiian astronauts, but today is also the day to see the power of NASA," Thompson said. "It's really important that people understand the need to explore."

Veach's widow, Alice, took part in the ceremony along with her daughter and three grandchildren.

"I really feel Lacey's spirit here today," she said. "The friendships that he made stayed with him always. Everyone is Hawaiian today."

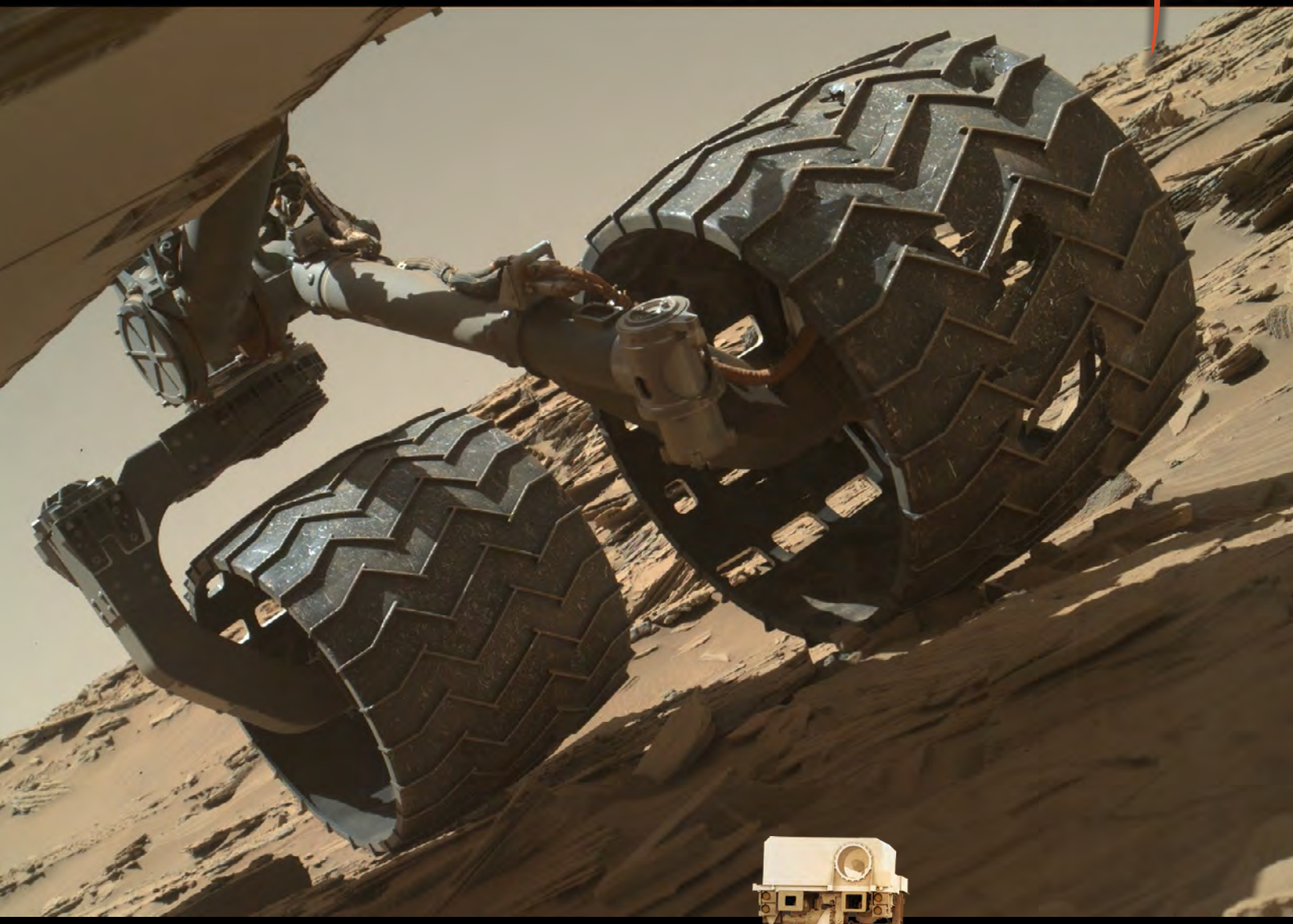
The widow of astronaut Lacy Veach, Ann Veach, accepts gifts from Capt. Nainoa Thompson of the Hokulea during a service honoring Hawaiian astronauts Veach and Ellision Onizuka. Photo credit: NASA/Ben Smegelsky

"The purposes that we sail and that they fly outweighs the risk. The other piece is that success is really determined by how well you prepare."

–Nainoa Thompson
Captain of the Hakulea

For more information, go to http://www.nasa.gov/commercialcrew

JOURNEY TO MARS



The team operating NASA's Curiosity Mars rover uses the MAHLI camera on the rover's arm to check the condition of the wheels at routine intervals. This image of the left-middle and left-rear wheels is part of an inspection set taken on April 18 while the rover was on "Naukluft Plateau." NASA's Curiosity Mars rover has nearly finished crossing a stretch of the most rugged and difficult-to-navigate terrain encountered during the mission's 44 months on Mars. Photo credits: NASA/JPL-Caltech/MSSS

For more photos and how curiosity crossed a stretch of the most rugged and difficult-to-navigate terrain to date, go to

http://go.nasa.gov/1rBW3Eb

PLANNING IN CONCERT

Prospective partners attend Partnership Landscape Forum

BY LINDA HERRIDGE

More than 20 partners and prospective partners participated in a Partnership Landscape Forum hosted by the Center Planning and Development Directorate (CPD) at Kennedy Space Center on April 7. The workshop was led by CPD Director Scott Colloredo, with welcoming remarks by Kennedy Center Director Bob Cabana.

"The landscape here at the Kennedy Space Center has changed tremendously in the last five years. We really are a multi-user spaceport and now we're moving into a new phase of working agreements, Cabana said. "We've put the infrastructure in place to help make that happen. This is really an exciting time."

Representatives from various Kennedy organizations shared information on the requirements necessary to do business with the center, including agreement approach and framework; commercial operations, safety and mission assurance requirements; and a perspective from the Federal Aviation Administration (FAA). Presentations also covered Kennedy's payload services capabilities, the Universal Propellant Servicing System developed for use at Launch Pad 39C and other launch locations, and the autonomous flight termination system that is available to customers through the center's Technology Transfer Office.

"We're counting on you, our current and future partners represented here today, to help shape the future of Kennedy and the whole space coast," Colloredo said.

Government and academia forum participants included the U.S. Air Force 45th Space Wing, FAA, Florida Department of Transportation, Space Florida, the Space Coast Economic Development Commission and Embry-Riddle Aeronautical University.

Industry attendees included Blue Origin, Boeing, Ensco, Gilmour Space Corp., Greenboard Enterprise, Masten, Micro Aerospace Solutions, Orbital ATK, Rocket Crafters Inc., Rocket Lab USA, Space Systems Alliance, SpaceX, TrailBlazer Technologies, United Launch Alliance and Virgin Galactic.

Attendees were encouraged to ask questions and participate in a roundtable discussion.

"Thank you for coming out today to share your ideas. Your feedback will help make this multi-user spaceport successful," said Kennedy Deputy Director Janet Petro. "We want to be the place that people want to come to do business."

“We want to be the place that people want to come to do business.”

– Janet Petro
Deputy Director Kennedy Space Center

Scott Colloredo, director of the Center Planning and Development Directorate at Kennedy Space Center, listens to a question from one of the participants during the Partnership Landscape Forum V on April 7. Photo credit: NASA/ Frankie Martin

LESSONS LEARNED

STS-1 Team Members inspire, share experiences learned with workforce

BY LINDA HERRIDGE

The first space shuttle mission, STS-1, launched April 12, 1981, at 7 a.m. EST, 35 years ago, from Launch Pad 39A at Kennedy Space Center. Space shuttle Columbia carried two American heroes, Commander John Young and Pilot Bob Crippen, on a two-day mission to test the new launch vehicle's capabilities. Columbia glided to a landing April 14 at Edwards Air Force Base in California, marking the start of 30 years of space shuttle missions.

One of those heroes, Bob Crippen, was the keynote speaker during the STS-1 Legacy and Lessons Learned event April 8 at Kennedy. Crippen shared memories of his selection as the pilot for the first space shuttle mission, overall mission highlights and lessons learned from that mission and subsequent shuttle flights.

"Serving as the pilot on the STS-1 mission was one of the highlights of my life," Crippen said. "It was a great flight. Looking back, I'm very proud of the program."

Crippen continued his career as a NASA astronaut and served as commander for three more shuttle missions: STS-7, from June 18-24, 1983; STS-41C, from April 6-13, 1984; and STS-41G, from Oct. 6-13, 1984.

Crippen became a NASA astronaut in September 1969. He was a member of the astronaut support crew for the Skylab 2, 3 and 4 missions and for the Apollo-Soyuz Test Project.

Kennedy Center Director Bob Cabana led an informal discussion with several STS-1 team members who shared stories and lessons learned from the early days of the shuttle program. Participants were John Tribe, chief engineer for Boeing/Rockwell Launch Support Services; Dick Lyon, director of Shuttle Logistics Operations; Roy Tharpe, Shuttle Test Support manager;

Left: Legendary astronaut, former Kennedy Space Center Director and STS-1 Pilot Bob Crippen speaks to the audience during the STS-1 Legacy and Lessons Learned event April 8 at the Training Auditorium at Kennedy. Crippen, along with several STS-1 launch team members shared their memories and valuable lessons learned with a new generation of NASA, contractor and commercial crew employees. The event helped pay tribute to the STS-1 mission and its iconic role in leading the space shuttle into an amazing 30 year history of space exploration. Photo credit: NASA/Frankie Martin

Right: On April 12, 1981, astronauts John Young and Bob Crippen launched into space on space shuttle Columbia on the STS-1 mission-NASA's first mission aboard a reusable spacecraft. In this image, the two solid rocket boosters are aglow after being jettisoned. Photo credit: NASA

Opposite: Kennedy Space Center Director Bob Cabana, far left, stands with STS-1 team members at the conclusion of the STS-1 Legacy and Lessons Learned event April 8 at the Training Auditorium at Kennedy. To his right, are Roy Tharpe, STS-1 shuttle test support manager; Jim Harrington, STS-1 vehicle manager; John Conway, STS-1 director of Information Systems; John Tribe, STS-1 chief engineer for Boeing/Rockwell Launch Support Services; STS-1 Pilot Bob Crippen; Dick Lyon, STS-1 director of shuttle logistics operations; Bob Seick, STS-1 shuttle project engineer; and Hugh Harris, STS-1 launch commentator with public affairs. Crippen, along with the STS-1 launch team members shared their memories and valuable lessons learned with a new generation of NASA, contractor and commercial crew employees. The event helped pay tribute to the STS-1 mission and its iconic role in leading the space shuttle into an amazing 30 year history of space exploration. Photo credit: NASA/Frankie Martin

Jim Harrington, STS-1 vehicle manager; John Conway, director of Information Systems; and Bob Seick, STS-1 Shuttle Project engineer and launch director for 52 flights beginning in February 1984.

Lyon said creating working groups that met regularly helped the team work together and built comradery to get the job done. Conway said that teamwork and give-and-take helped to reach a consensus during creation of the new shuttle launch processing system.

"As a NASA employee, I was trying to interface with the vehicle processing contractor," Harrington said. "It was important to become a team member and be involved on a day-to-day basis to help things go smoothly."

During a one-on-one conversation, Crippen said the lessons learned from STS-1 and subsequent shuttle launches include the importance of face-to-face communication and realizing that space exploration is a dangerous business.

"It was the most audacious test flight," Cabana said. "We don't forget the history of our past as we move forward with the Space Launch System (SLS)."

Crippen said: "That was then, this is now. We really need the Orion and SLS."

Hugh Harris, worked in NASA Public Affairs and was the launch commentator for STS-1. He shared memories of the arrival of space shuttle Columbia and the events leading up to launch day.

"It was a very interesting and jittery time," Harris said. "From a public relations viewpoint, an important lesson is making sure to involve people, the general public, in the program."

Harris said that NASA astronauts are the surrogates for finding the worlds of tomorrow, and that the exploration component of the space program is what excites people.

The event was coordinated by NASA engineer Mike Ciannilli, who is the manager for the Apollo, Challenger, Columbia Lessons Learned program at Kennedy.

"A great measure of our current success rests on the giants who came before us," Cinnelli said. "Our mission is to innovatively share the missions from the past to achieve more mission success in the future."

Initial Effort

Shepard's Mercury flight was first step on long Journey to Mars

BY BOB GRANATH

According to an ancient Chinese proverb, "A journey of a thousand miles must begin with a single step." NASA is preparing for a journey to Mars, a planet that is 49 million miles from Earth. That journey began 55 years ago with a single, 116-mile "step" into space on May 5, 1961.

Amid a backdrop for the effort to put a human in space was the Cold War. The Soviet Union also was working to put the first human in space, and they did on April 12, 1961. Cosmonaut Yuri Gagarin was launched aboard a spacecraft named Vostok (Russian for "east") and completed an entire orbit of the Earth, landing after a flight of one hour and 29 minutes.

Three weeks later, NASA astronaut Alan Shepard flew aboard a Mercury spacecraft he named Freedom 7. It was a short, 15-minute flight into space, but it was a "small step" that has led to many "giant leaps."

Following the success of Shepard's flight, President John F. Kennedy knew he needed a bold response to the challenge of the Soviet Union as the Space Race began to heat up.

"We knew we were in a competitive situation," said Dr. Kurt Debus, NASA's Launch Operations director at the time. "But, we never permitted the pressure to make us take risks that might endanger Shepard's life or the success of the mission."

Debus, who would go on to serve as the first director of the Kennedy Space Center, knew he and the Project Mercury team were on the verge of something historic.

"We were proud that we were permitted to do some of the pioneering work and aware that we were at the threshold of something very important," he said.

When Ike Rigell, chief of Project Mercury Electrical Network Systems, looked back at Shepard's flight, he expressed similar emotions.

"This was a very significant flight, because the country needed this," he said. "The whole free world needed this flight at that time."

Following a delay due to unfavorable weather on May 2, 1961, NASA was ready for another attempt to launch Mercury Redstone-3.

America's first piloted spaceflight launched May 5, 1961 from Cape Canaveral Air Force Station's Launch Complex 5 with NASA astronaut Alan Shepard aboard Mercury Redstone-3. Photo credit: NASA

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Shepard climbed aboard Freedom 7 at 5:15 a.m. for the planned 7:20 a.m. liftoff from Launch Complex 5 at Cape Canaveral Air Force Station. But the launch was held for an hour to allow cloud cover to clear. Next, an inverter in the electrical system had to be repaired. Once the countdown began again, another hold was required to recheck a computer at Goddard Space Flight Center. The Greenbelt, Maryland-based center was responsible for management and operations of Project Mercury's communication networks.

Shepard Reaches Space

Finally, at 9:34 a.m., the Mercury Redstone rocket roared to life with 78,000 pounds of thrust.

"Roger, liftoff and the clock has started," Shepard radioed back to Mercury Control at the Cape.

An estimated 45 million American television viewers watched as the sleek, 83-foot launch vehicle rose into the blue Florida sky. Thousands more "bird watchers" had flocked to Cocoa Beach and Port Canaveral to witness the historic event.

After the flight, Shepard reported the launch phase went smoothly.

"The cockpit section experienced no vibration, and I did not even have to turn up my radio receiver to full volume to hear the radio transmissions."

During the rocket's acceleration, Shepard was subjected to 6.3 *g*, or 6.3 times his normal weight, just before shut down of the Redstone engine, two minutes and 22 seconds after liftoff.

"Ten seconds later, the spacecraft separated from the launch vehicle," Shepard said.

Soon after, America's first space traveler got his first view of the Earth.

"What a beautiful view," Shepard said.

Now weightless in space, Shepard took control of the spacecraft with a hand controller.

"I made this manipulation one axis at a time, switching to pitch, yaw and roll in that order until I had full control of the craft," he said.

These options were not available to Gagarin on Vostok.

Freedom 7's retrorockets fired five minutes, 15 seconds after liftoff to begin the return to Earth. Strapped atop the heat shield, the retro pack was successfully jettisoned for the return through the atmosphere.

"The re-entry and its attendant acceleration pulse of 11 *g* was not unduly difficult," Shepard said, "and I noticed no loss of peripheral vision."

An experienced Naval aviator, Shepard reported that the splashdown in the Atlantic Ocean "did not seem any more severe than a catapult shot from an aircraft carrier."

Helicopters dispatched from the recovery carrier, the USS Lake Champlain, were soon hovering above the floating Mercury spacecraft.

After the main hatch was blown off, Shepard climbed out

"This was a very significant flight, because the country needed this. The whole free world needed this flight at that time."

– Ike Rigell
Project Mercury Electrical Network Systems Chief

President John F. Kennedy pins NASA's Distinguished Service Medal on the jacket of Alan Shepard in a Rose Garden ceremony at the White House on May 8, 1961. Looking on is Shepard's wife, Louise. Photo credit: NASA

Mercury Atlas-6 lifts off on Feb. 20, 1962 carrying astronaut John Glenn on America's first orbital spaceflight. Photo credit: NASA

Project Gemini helped NASA perfect skills such as orbital rendezvous. The Gemini VII spacecraft was photographed by the crew of Gemini VI on Dec. 15, 1965. The two spacecraft are about 37 feet apart in this image. Photo credit: NASA/Tom Stafford

and into a sling and was hoisted into a Marine helicopter. Both astronaut and Freedom 7 were flown to the deck of the Lake Champlain where sailors cheered the arrival.

The flight of Mercury Redstone-3 lasted 15 minutes, 22 seconds with Freedom 7 ascending to an altitude of 116 miles, splashing down 302 miles from Cape Canaveral.

Three days after the flight of Freedom 7, President Kennedy presented Shepard with the NASA Distinguished Service medal in a ceremony at the White House.

Opening a New Frontier

Walt Kapryan, who was capsule project engineer for Shepard's flight, recalled the excitement of being a part of America's first human spaceflight.

"We felt we were on the threshold of something very important," Kapryan said. "We were on the threshold of opening a new frontier."

Kapryan, who went on to become director of Launch Operations at Kennedy, soon learned that feeling was well founded.

During a joint session of Congress on May 25, 1961, Kennedy challenged the nation to take the next steps in the journey in space by "landing a man on the moon and returning him safely to the Earth." In remarks at Rice University in Houston on Sept. 12, 1962, Kennedy put in perspective the challenge that was ahead.

"We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard," he said, "because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win."

As Project Mercury's orbital flights transitioned to the technological advances of Project Gemini, NASA honed skills in maneuverable spacecraft, spacewalking, rendezvous, docking and flights of up to two weeks.

Then came the giant leap to the moon.

Leaving Earth

On Dec. 21, 1968, Apollo 8 astronauts Frank Borman, Jim Lovell and Bill Anders became the first humans to leave Earth orbit and make the 240,000 mile journey to the moon. The trio orbited the moon 10 times on Christmas Eve.

Kennedy's goal was achieved in July 1969 when Apollo 11 launched from Kennedy to land on the moon. While Mike Collins remained aboard the command module in lunar orbit, Neil Armstrong and Buzz Aldrin landed in the area known as the Sea of Tranquility. Soon after, Armstrong descended the lunar module's ladder.

"That's one small step for (a) man, one giant leap for mankind," said Armstrong as he stepped onto the lunar soil.

It was slightly more than eight years since Shepard's small, 15-minute step in what was becoming an ongoing journey. By

December 1972, 12 NASA astronauts had walked on the moon.

In the mid-1970s, NASA's focus returned to low-Earth orbit with the prototype space station, Skylab. In July 1975, a joint mission, called the Apollo-Soyuz Test Project, turned into an opportunity to develop international cooperation with the rendezvous and docking of a U.S. Apollo with a Soviet Soyuz spacecraft.

A Highway to Space

A new era in spaceflight began on April 12, 1981, with the launch of NASA astronauts John Young and Bob Crippen on the first space shuttle mission. The reusable spacecraft opened a highway to space traveled by shuttle crews for more than 30 years.

Launching satellites, astronomical observatories and research labs provided opportunities for more advances in developments of space technology, none more crucial to understanding the universe than deployment of the Hubble Space Telescope.

Lifting off from Kennedy on April 24, 1990, the STS-31 crew deployed the 24,490-pound observatory in an orbit 347 miles above the Earth. Avoiding distortions of the atmosphere, Hubble has an unobstructed view peering to planets, stars and galaxies, some more than 13.4 billion light years away.

After only nine space shuttle missions, President Ronald Reagan asked NASA to use the shuttle's capabilities for the agency's next giant leap.

"I am directing NASA to develop a permanently manned space station," he said in his State of the Union address on Jan. 25, 1984. "Nowhere can we so effectively demonstrate our technological leadership and ability to make life better on Earth."

As plans for the orbiting outpost progressed, it became a global effort known as the International Space Station, or ISS.

Kennedy's director, Bob Cabana, a former space shuttle astronaut, considers international cooperation an essential element of space exploration going forward.

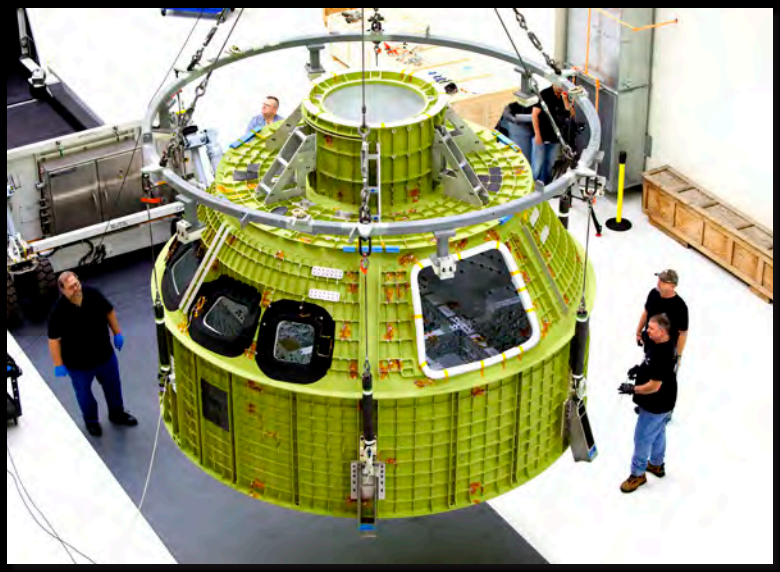
"I believe it's the model for how we are going to explore beyond planet Earth," he said. "Right now we've got the United States, Japan, Canada, Russia, ESA and all its partners working together as one up there. When we leave planet Earth, we're not going to leave as any one nation, we're going to leave as the people from planet Earth."

The 11 members of ESA – the European Space Agency – that participate in the ISS program include Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom.

The station's first element, the functional cargo block named "Zarya," was placed in orbit by Russia on Nov. 20, 1998. Two weeks later, the space shuttle Endeavour lifted off from Kennedy with Cabana as commander. The crew carried with them the first American-launched station element, node 1, called "Unity." During the 12-day STS-88 shuttle flight, the crew connected Unity to Zarya.

As a Saturn V rocket launches Apollo 8 on Dec. 21, 1968, Frank Borman, Jim Lovell, and Bill Anders became the first astronauts to leave Earth orbit and circle the moon. Photo credit: NASA

Apollo 11 astronaut Buzz Aldrin deploys the Passive Seismic Experiment Package on July 20, 1969. In the center background is the lunar module, Eagle. Photo credit: NASA/Neil Armstrong



The Orion crew module pressure vessel for NASA's Exploration Mission 1 has arrived inside the Neil Armstrong Operations and Checkout Building high bay at Kennedy Space Center. A lifting crane has been attached to the crew module for transfer to a test stand called the birdcage. Technicians and engineers with Orion's manufacturer, Lockheed Martin, will begin preliminary checkout of the crew module. Photo credit: NASA/Bill White

This artist concept represents work taking place on Mars. It is based on current studies in developing hardware and operations necessary for a sustainable human presence on the Red Planet. Image credit: NASA

As ISS construction continued, permanent occupancy of the space station began with the Expedition 1 crew launched Oct. 31, 2000, establishing a continuous human presence conducting landmark research in space that endures today.

"In addition to being just a phenomenal scientific laboratory, the space station is a superb engineering test bed," Cabana said. "We're proving the systems that we need to explore beyond our own planet to stay in space for extended periods of time."

The Next Steps for NASA

Speaking at the Florida spaceport on April 15, 2010, President Barack Obama outlined the course his administration was charting for NASA's next steps in space exploration.

"By 2025, we expect new spacecraft designed for long journeys to allow us to begin the first-ever crewed missions beyond the moon into deep space," he said. "By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth. And a landing on Mars will follow."

To achieve that next giant leap, NASA is developing the Orion crew vehicle, Space Launch System, or SLS, rocket and Exploration Ground Systems that will one day allow astronauts to travel beyond low-Earth orbit. The SLS is a new heavy-lift rocket that will be capable of sending humans aboard Orion to deep-space destinations such as an asteroid and Mars.

Launched atop a Delta IV Heavy rocket on Dec. 5, 2014, an Orion spacecraft performed a near-flawless flight test on its first journey to space. During the two-orbit, four-and-a-half hour mission, engineers evaluated systems critical to crew safety, the launch abort system, the heat shield and the parachute system.

The next Orion flight will be Exploration Mission 1. On Feb. 1, the pressure vessel for that Orion spacecraft arrived at Kennedy. Late in 2018, this spacecraft will liftoff atop NASA's SLS rocket on the launch vehicle's maiden voyage.

"This is our full-up Orion spacecraft on top of the SLS rocket, the most powerful rocket ever launched," said Scott Wilson, NASA's manager of Orion Production Operations at Kennedy. "This will be our test to wring out the vehicle to make sure it's safe to put humans on the very next flight."

The long journey to Mars began with a single step in 1961. In the 55 years since Alan Shepard's sub-orbital flight, NASA has followed with many giant leaps forward.

The ongoing endeavor is designed to improve lives on Earth by advancing scientific knowledge and discovery, developing new technologies, providing economic opportunities, and continuing U.S. leadership in the peaceful, international exploration of space.

JOURNEY TO MARS

Orion
AMERICA'S NEXT GENERATION SPACECRAFT

NASA is building a new exploration spacecraft that will take humans farther into space than ever before. The Orion spacecraft will be the safest and most advanced space vehicle ever built. Orion will launch atop the Space Launch System (SLS) and will carry four astronauts on deep-space missions to places like asteroids, the moon and Mars.

For more information visit:
www.nasa.gov/orion

Twitter:
@NASA_Orion

Facebook:
facebook.com/NASAOrion

Space Launch System (SLS)
AMERICAN'S NEXT GENERATION ROCKET

NASA's Space Launch System (SLS) will provide a safe, affordable backbone for sustainable human space exploration. The SLS will launch astronauts in the Orion spacecraft and also will carry the cargo needed to support exploration beyond Earth's orbit. The SLS will be the most powerful rocket ever built.

For more information visit:
www.nasa.gov/sls

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Ground Systems Development & Operations (GSDO)
AMERICA'S SPACEPORT OF THE FUTURE

NASA's Ground Systems Development and Operations Program is preparing Kennedy Space Center to process and launch the next-generation vehicles and spacecraft designed to achieve NASA's goals for space exploration.

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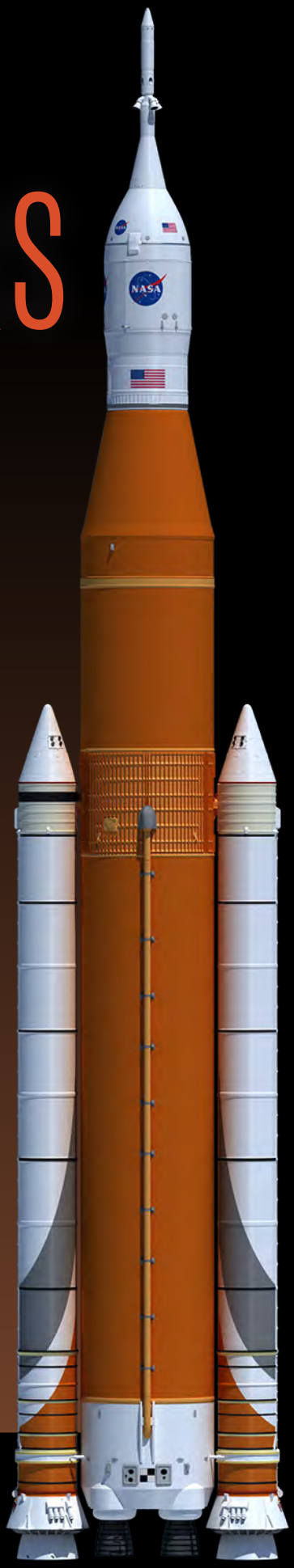

SHEPARD'S MERCURY FLIGHT WAS FIR

NASA is preparing for a journey to Mars, a planet that is 49 million miles from Earth. 5, 1961. In the years that followed, NASA astronauts have taken many giant leaps. W conduct research that is helping develop the technologies to continue the journey to

Astronaut Alan Shepard during the 15-minute Mercury Redstone-3 flight on May 5, 1961, in which he became the first American in space. Lifting off from Cape Canaveral Air Force Station, his Freedom 7 spacecraft splashed down 302 miles downrange.
Photo credit: NASA

Astronaut John Glenn climbs aboard his Friendship 7 spacecraft on Feb. 20, 1962. He became the first American to orbit the Earth.
Photo credit: NASA

Apollo 15 lunar module pilot Jim Irwin salutes the U.S. flag on Aug. 1, 1971. The lunar module, Falcon, is visible on the right. Irwin and mission commander David Scott were among 12 Americans to walk on the moon between July 1969 and December 1972.
Photo credit: NASA/David Scott

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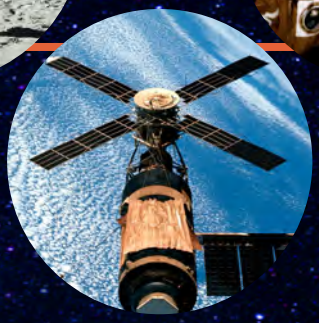
Photo credit: NASA

President John F. Kennedy congratulates astronaut Alan Shepard, the first American in space, after his ride in the Freedom 7 spacecraft. Three weeks after the historic flight, Kennedy put NASA on the road to the moon.
Photo credit: NASA

Gemini IV Astronaut Ed White floats in the microgravity of space outside the spacecraft. His spacewalk was another step in advancing space technology.
Photo credit: NASA/Jim McDivitt



An overhead view of the Skylab space station in Earth orbit as photographed from the Skylab 4 command module during the final fly-around before returning home Feb. 8. 1974. From June 1973 to February 1974, three crews spent a total of 171 days aboard during three Skylab missions.
Photo credit: NASA

ST STEP ON THE LONG JOURNEY TO MARS

That journey began 55 years ago with a single, 15-minute "small step" into space on May ork aboard the International Space Station now is allowing crews from around to world to Mars.

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President Ronald Reagan and first lady Nancy Reagan welcome STS-4 astronauts Ken Mattingly, right, and Hank Hartsfield after the July 4, 1982, landing of the space shuttle Columbia at Edwards Air Force Base, California. During his State of the Union address on Jan. 25, 1984, Reagan directed NASA to develop a permanently manned space station.
Photo credit: NASA

Speaking on April 15, 2010, at the Kennedy Space Center, President Barack Obama outlines the course his administration is charting for NASA and the future of U.S. leadership in human spaceflight. Behind him is a mock-up of an Orion spacecraft.
Photo credit: NASA/Jim Grossmann

This artist rendering depicts work during a future mission to Mars.
Image credit: NASA

A new era in spaceflight began with the April 12, 1981, liftoff of the space shuttle Columbia. Astronauts John Young and Bob Crippen opened a highway to space traveled by shuttle crews for more than 30 years.
Photo credit: NASA

NASA astronaut Tim Kopra sets up hardware for the Burning and Suppression of Solids – Milliken, or BASS-M, experiment on the International Space Station. The BASS-M investigation tests flame-retardant cotton fabrics to determine how well they resist burning in microgravity. Results benefit research on flame-retardant textiles that can be used on Earth and in space.
Photo credit: NASA

This artist rendering shows an aerial view of the liftoff of Space Launch System (SLS) from Launch Pad 39B at the Kennedy Space Center. On the maiden voyage of the SLS, the rocket will launch an Orion spacecraft on a flight beyond the moon.
Image credit: NASA/Marshall Space Flight Center

For the 26th birthday of NASA's Hubble Space Telescope, astronomers are highlighting a Hubble image of an enormous bubble being blown into space by a super-hot, massive star. The Hubble image of the Bubble Nebula, or NGC 7635, was chosen to mark the 26th anniversary of the launch of Hubble into Earth orbit by the STS-31 space shuttle crew on April 24, 1990 "As Hubble makes its 26th revolution around our home star, the sun, we celebrate the event with a spectacular image of a dynamic and exciting interaction of a young star with its environment. The view of the Bubble Nebula, crafted from WFC-3 images, reminds us that Hubble gives us a front row seat to the awe inspiring universe we live in," said John Grunsfeld, Hubble astronaut and associate administrator of NASA's Science Mission Directorate at NASA Headquarters, in Washington, D.C. The Bubble Nebula is seven light-years across — about one-and-a-half times the distance from our sun to its nearest stellar neighbor, Alpha Centauri, and resides 7,100 light-years from Earth in the constellation Cassiopeia. Photo credit: NASA

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