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KENNEDY SPACE CENTER'S

SPACEPORT magazine

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KENNEDY SPACE CENTER'S

SPACEPORT MAGAZINE

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NASA'S LAUNCH SCHEDULE

Targeted Date: Dec. 3, 5:55 p.m. EST
Mission: Fourth Orbital ATK Commercial Resupply Services Flight to ISS
Description: The mission will be the first flight of the enhanced variant of Orbital ATK's Cygnus advanced maneuvering spacecraft, capable of delivering more than 7,700 pounds of essential crew supplies, equipment and scientific experiments to the International Space Station. The Atlas V will launch from Cape Canaveral Air Force Station in Florida during a 30-minute window.
http://go.nasa.gov/J37GNY

Date: Dec. 15
Mission: Expedition 46 Launch to the ISS
Description: NASA astronaut Tim Kopra, ESA astronaut Tim Peake and Yuri Malenchenko of Roscosmos will launch to the ISS aboard a Soyuz spacecraft from the Baikonur Cosmodrome, Kazakhstan.
http://go.nasa.gov/1ltsxly

Date: March 2016
Mission: InSight (Interior Exploration Using Seismic Investigations, Geodesy and Heat Transport)
Description: The mission will study the deep interior of Mars to advance understanding of the early history of all rocky planets, including Earth.
http://go.nasa.gov/1ltsDcR

Date: September 2016
Mission: OSIRIS-REx
Description: The mission will study Bennu, a near-Earth asteroid that's about one-third of a mile across.
http://go.nasa.gov/1ltsRkl

I am KENNEDY SPACE CENTER

JACKIE QUINN

I have degrees in environmental and civil engineering, and during the past 25 years, I have had the privilege of working a variety of jobs with many super-smart and talented folks at the Kennedy Space Center.

I claim time well spent on the Environmental Controls and Life Support System for the Space Shuttle. I look back and see engineering skills I deployed as a civil engineer when I designed and supervised the construction of the Black Point wildlife road repaving job in the early 1990s. It's fun seeing the design choices I made two decades ago hold up! I reminisce about the impacts of the environmental cleanup projects I enjoyed working on as part of Kennedy's Environmental Management Office. And then I glance back at my more recent technology development career, and I am humbled by the opportunities this agency has offered me.

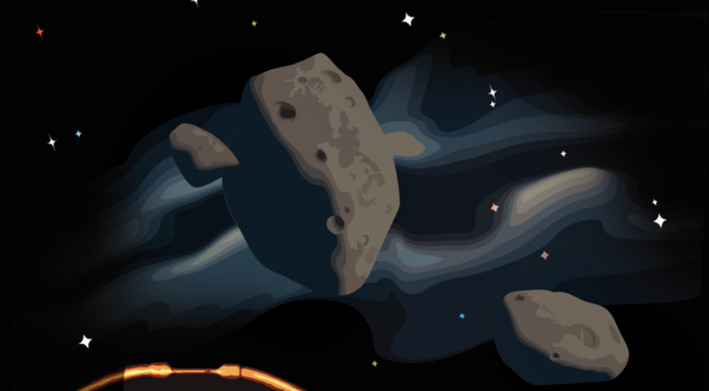
I attended graduate school in 1995 as a Hugh Dryden Memorial Science Fellowship recipient. This propelled me into the applied research and technology development sector, and gave me the opportunity that led to the development of Emulsified Zero Valent Iron, or EZVI, an environmental groundwater cleanup technology that would win NASA's 2005 Government and Commercial Invention of the Year awards.

Although I continue to dabble in the environmental technology development area, I spend most of my time as the Project Manager for the RESOLVE, or Regolith and Environment Science and Oxygen Lunar Volatiles Extraction, payload, which will be the primary payload onboard the 2020 Resource Prospector mission. I am surrounded by engineers and scientists from multiple centers that truly embody the excellence that NASA represents, and am humbled by this opportunity. The people who work in the space program are some of the most motivated and driven individuals I have ever met, and I am so fortunate to be a part of this team.

NASA'S JOURNEY CONTINUES

SEEKING SKY WALKERS

ACCEPTING APPLICATIONS
BEGINNING DECEMBER 14



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Astronaut candidates wanted for future space missions

Applications for consideration as a NASA astronaut will be accepted at: http://www.usajobs.gov.

See if you have what it takes: https://youtu.be/QjECZVitU00

In anticipation of returning human spaceflight launches to American soil, and in preparation for the agency's journey to Mars, NASA announced it will soon begin accepting applications for the next class of astronaut candidates. With more human spacecraft in development in the United States today than at any other time in history, future astronauts will launch once again from the Space Coast of Florida on American-made commercial spacecraft, and carry out deep-space exploration missions that will advance a future human mission to Mars.

The agency will accept applications from Dec. 14 through mid-February and expects to announce candidates selected in mid-2017. Applications for consideration as a NASA Astronaut will be accepted at: http://www.usajobs.gov.

The next class of astronauts may fly on any of four different U.S. vessels during their careers: the International Space Station, two commercial crew spacecraft currently in development by U.S. companies, and NASA's Orion deep-space exploration vehicle.

From pilots and engineers, to scientists and medical doctors, NASA selects qualified astronaut candidates from a diverse pool of U.S. citizens with a wide variety of backgrounds.

"This next group of American space explorers will inspire the Mars generation to reach for new heights, and help us realize the goal of putting boot prints on the Red Planet," said NASA Administrator Charles Bolden. "Those selected for this service will fly on U.S. made spacecraft from American soil, advance critical science and research aboard the International Space Station, and help push the boundaries of technology in the proving ground of deep space."

The space agency is guiding an unprecedented transition to commercial spacecraft for crew and cargo transport to the space station. Flights in Boeing's CST-100 Starliner and SpaceX Crew Dragon will facilitate adding a seventh crew member to each station mission, effectively doubling the amount of time astronauts will be able to devote to research in space.

Future station crew members will continue the vital work advanced during the last 15 years of continuous human habitation aboard the orbiting laboratory, expanding scientific knowledge and demonstrating new technologies. This work will include building on the regular six-month missions and this year's one-year mission, currently underway aboard the station, which is striving for research breakthroughs not possible on Earth that will enable long-duration human and robotic exploration into deep space.

In addition, NASA's Space Launch System rocket and Orion spacecraft, now in development, will launch astronauts on missions to the proving ground of lunar orbit where NASA will learn to conduct complex operations in a deep space environment before moving on to longer duration missions on its journey to Mars.

"This is an exciting time to be a part of America's human space flight program," said Brian Kelly, director of Flight Operations at NASA's Johnson Space Center in Houston. "NASA has taken the next step in the evolution of our nation's human spaceflight program — and our U.S. astronauts will be at the forefront of these new and challenging space flight missions. We encourage all qualified applicants to learn more about the opportunities for astronauts at NASA and apply to join our flight operations team."

To date, NASA has selected more than 300 astronauts to fly on its increasingly challenging missions to explore space and benefit life on Earth. There are 47 astronauts in the active astronaut corps, and more will be needed to crew future missions to the space station and destinations in deep space.

Astronaut candidates must have earned a bachelor's degree from an accredited institution in engineering, biological science, physical science or mathematics. An advanced degree is desirable. Candidates also must have at least three years of related, progressively responsible professional experience, or at least 1,000 hours of pilot-in-command time in jet aircraft. Astronaut candidates must pass the NASA long-duration spaceflight physical.

For more information about a career as a NASA astronaut, and application requirements, visit: http://www.nasa.gov/astronauts.

SPUDS IN SPACE

NASA plant researchers explore question of deep-space food crops

BY LINDA HERRIDGE

NASA plant physiologist Dr. Ray Wheeler and fictional astronaut Mark Watney from the movie "The Martian" have something in common — they are both botanists. But that's where the similarities end. While Watney is a movie character who gets stranded on Mars, Wheeler is the lead for Advanced Life Support Research activities in the Exploration Research and Technology Program at Kennedy Space Center, working on real plant research.

"The Martian movie and book conveyed a lot of issues regarding growing food and surviving on a planet far from the Earth," Wheeler said. "It's brought plants back into the equation."

As NASA prepares the Space Launch System rocket and Orion spacecraft for Exploration Mission-1, it's also turning its attention to exploring the possibilities of food crops grown in controlled environments for long-duration missions to deep-space destinations such as Mars.

Wheeler and his colleagues, including plant scientists, have been studying ways to grow safe, fresh food crops efficiently off the Earth. Most recently, astronauts on the International Space Station harvested and ate a variety of red romaine lettuce that they activated and grew in a plant growth system called Veggie.

Wheeler, who has worked at Kennedy since 1988, was among the plant scientists and collaborators who helped get the Veggie unit tested and certified for use on the space station. The plant chamber, developed by Orbitec through a NASA Small Business Innovative Research Program, passed safety reviews and met low power usage and low mass requirements for use on the space station.

Aside from the chamber, the essentials needed for growing food crops, whether on the Earth or another planet, such as Mars, are water, light and soil, along with some kind of nutrients to help them grow.

POTATO CROP STUDIES

What kind of crops could be grown in space or on another planet? Potatoes, sweet potatoes, wheat and soybeans would all be good according to Wheeler because they provide a lot of carbohydrates, and soybeans are a good source of protein.

Also, potatoes are tubers, which means they store their edible biomass in underground structures. Wheeler said potatoes could produce twice the amount of food as some seed crops when given equivalent light. After salad crops that are now being studied, they are the next category of minimally processed food crops and could be consumed raw.

A variety of red potatoes called Norland were grown in the Biomass Production Chamber inside Hangar L at Cape Canaveral Air Force Station in Florida during a research study in 1992. Photo credit: NASA

"You could begin to grow potatoes, wheat and soybeans, things like that, and along with the salad crops, you could provide more of a complete diet," Wheeler said.

Wheeler has spent a lot of time studying different ways to grow potatoes. Most of his studies took place during the late 1980s through the early 2000s inside Hangar L at Cape Canaveral Air Force Station in Florida. The lab was relocated to the Space Life Sciences Laboratory in 2003. A major portion of the labs were then relocated to the Space Station Processing Facility in 2014 to become part of the Exploration Research and Technology Programs Directorate at Kennedy.

Many of the early potato crop studies were done at the University of Wisconsin, where Wheeler worked prior to coming to Kennedy. Plant scientists at Kennedy used these fundamental findings as a starting point for their studies, and in particular, a variety called Norland red potatoes, using a large plant chamber called the Biomass Plant Production Chamber.

The Biomass Production Chamber originally was a hypobaric test chamber used during the Mercury Project. Including its pedestal, the chamber is 28 feet tall. It was later modified to grow plants in the mid-1980s. Air circulation ducts and fans, high pressure sodium lamps, cooling and heating systems, and hydroponic trays and solution tanks were added. The chamber provided a tightly closed atmosphere for plant growth, which simulated what might be encountered in space.

"Providing food is a complex issue," Wheeler said. "We have to think about nutritional issues, what's acceptable and what tastes good. If nobody wants to eat it, that won't work."

WATER — A PRECIOUS RESOURCE

In the movie, the character chooses to use the regolith, or Martian soil, to grow the plants. In reality, the soil on Mars is essentially broken rock material, and lacks most of the nutrients needed to sustain plant growth.

Much of what Wheeler did in his potato studies involved growing the plants in shallow, tilted trays using a hydroponic recirculating system.

"With potatoes, it was a little bit more interesting in the sense that you can't use systems that require a lot of standing or deep water—potatoes don't like to be submerged," Wheeler said, "and we kept the nutrient water film very thin."

They did very well, as do many crops grown this way, according to Wheeler. But traveling in a spacecraft to another planet will put constraints on the quantity and weight of commodities that could be brought along. You can't pack everything you need for a long-duration spaceflight. Some resources will need to be recycled, acquired or made at the destination, a process called in-situ resource utilization.

"The recent discovery of water on Mars is a positive development," said Rob Mueller, senior technologist for Advanced Projects Development in the Exploration Research and Technology Program at Kennedy. "It can be used for making propellant, sustaining human life and growing crops."

But, Mueller noted, the water will not be pure and will have a brine composition. Perchlorates and other impurities are known to exist in the regolith on Mars, so these must be accounted for and mitigated before the water can be used.

Wheeler said one scenario could be that provisions such as water pumps and fertilizer salts are brought along on deep-

An artist concept depicts a greenhouse on the surface of Mars. Plants are growing with the help of red, blue and green LED light bars and a hydroponic cultivation approach. Image credit: SAIC

space trips, and the plants are grown hydroponically inside a protected environment. Martian soils might be used later as the growing systems expand.

"Growing plants on Mars is not a trivial matter," Mueller said.

PLANTS NEED LIGHT TO GROW

In open fields on Earth, light is plentiful. But out in space, use of direct sunlight for plant growth could be challenging. Yet having sufficient light will be required for growing plants quickly in space.

In 2007, a graduate student at the University of Colorado mapped the light intensity at the surface of Mars over two Martian years. Results showed that the Red Planet gets 43 percent of the sunlight that Earth receives due to its distance from the Sun, but has numerous areas at low latitudes that receive adequate light to grow plants.

"Mars gets significant dust storms, which could block a lot of sunlight, and that must be considered," Wheeler said. "That's an issue, even if we're using a photovoltaic system."

That's the reason why planetary problems and spacecraft that travel farther away from the sun, like Cassini, Galileo and New Horizons, didn't use photovoltaic type systems. Just like in the movie, they use radioactive thermal generators, also called RTGs, as power generators. It's a form of radioactive decay that generates heat, which is converted to electrical power.

"An alternate approach to sunlight would be to use electric light sources. High intensities of efficient LED lights could be used to help push the plants hard," Wheeler said. "This is an area where NASA has been really right up on the edge of research and development."

The Veggie plant growth system, currently on the space station, uses blue and red LED lights. Wheeler said using LED lights to grow plants was an idea that originated from a NASA-funded effort at the University of Wisconsin in the 1980s. The technology was patented with NASA-supported funds.

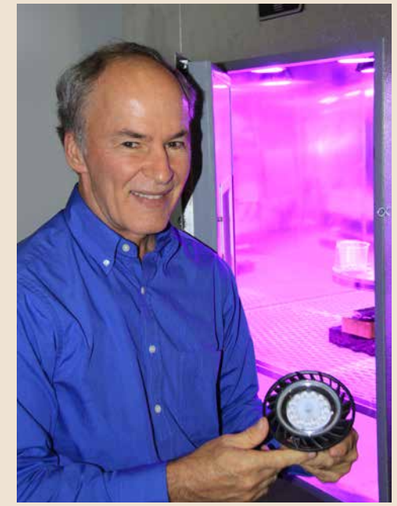
Kennedy's plant scientists also were one of the first groups to demonstrate vertical farming -- layers of plant trays with a water source and LED lighting. This type of farming is now being used in Japan, Korea, and China, and several facilities in North America.

PROTECTION FROM RADIATION

As if finding the right soil, water and lighting wasn't enough of a challenge, food crops also would need to be protected from ultraviolet radiation and kept inside a pressurized environment with adequate nutrients and appropriate lighting. The shelter would have to be able to withstand radiation and the extreme temperatures of a Martian environment.

"That's a big challenge for materials for a greenhouse-like structure. The thermal issues could be alleviated by having either a cover or clamshell that would go over it at night and open in the daytime," Wheeler suggested.

When nuclear power was emerging in the 1970s, there was a lot of interest in understanding the potential effects of radiation on living organisms, including plants. There are limits to what plants can take, and Wheeler said more research needs to be done on the tolerance of food crops to radiation.



Dr. Ray Wheeler, lead for Advanced Life Support Research activities at Kennedy Space Center, holds a red and blue LED light fixture inside a laboratory at the Space Station Processing Facility. The LED lights recently were used to study the effects of different ratios of red and blue light on plant growth and development. Photo credit: NASA/Jim Grossmann

THE 'EYES' HAVE IT

How do you regenerate your food source? If you consume everything over a period of time, you will eventually run out.

But there's something special about potato tubers. Potatoes have "eyes" or buds. If given enough time, the eyes sprout. Sections of potatoes containing at least one "eye" could be replanted so they can sprout and produce new plants. This process was illustrated in "The Martian," and actually is used by seed potato growers in field settings on Earth who then take their crops and sell them to production companies.

During the 1990s, NASA's potato studies with hydroponics got the attention of the Frito-Lay Company in Wisconsin. Wheeler consulted with the company on ways to produce clean, disease-free seed potato stock.

A SOURCE OF RECYCLING

Growing crops in space or on another planet could provide other benefits besides food. Plants could serve to provide oxygen and remove carbon dioxide from air sources.

While plants grow, they generate oxygen through photosynthesis, and they would scrub carbon dioxide out of the air inside a cabin environment. Wheeler said if you co-utilize them in the right manner, they could help process wastewater.

And as odd as it sounds, using wastewater, or even urine, as a source of nutrients for plant growth could be an option. Aboard the space station, U.S. astronauts use the Environmental Control and Life Support System — a system that collects and recycles used water, wastewater and urine.

While the recent movie made it seem like growing potatoes on Mars was a no-brainer, a lot of research has gone into making that a real possibility. With humans expected to plant boots on Mars in the next couple of decades, solving the challenges of growing plants in space today is critical to our journey to the Red Planet.

Flowers in Space

BY LINDA HERRIDGE

Flowers could be blooming on the International Space Station after the New Year.

On Nov. 16, NASA astronaut Kjell Lindgren activated the Veggie plant growth system and its rooting "pillows" containing Zinnia seeds on the space station.

It is the first time that a flowering crop experiment will be grown on the orbiting laboratory. Growing Zinnias in orbit will help provide precursory information about other flowering plants that could be grown in space.

"Growing a flowering crop is more challenging than growing a vegetative crop such as lettuce," said Gioia Massa, a Kennedy Space Center payload scientist for Veggie. "Lighting and other environmental parameters are more critical."

Lindgren turned on the red, blue and green LED lights, activated the water and nutrient system to Veggie, and will monitor the plant growth. The Zinnias will grow for 60 days, which is twice as long as the first and second crop of Outredgeous red romaine lettuce that grew on the space station.

During the growth cycle, the LED lights will be on for 10 hours and off for 14 hours in order to stimulate the plants to flower.

"Growing the Zinnia plants will help advance our knowledge of how plants flower in the Veggie growth system, and will enable fruiting plants like tomatoes to be grown and eaten in space using Veggie as the in-orbit garden," said Trent Smith, Veggie program manager at Kennedy.

Researchers also hope to gather good data regarding long-duration seed stow and germination, whether pollen could be an issue, and the impacts on crew morale. Growing tomato plants on the space station is planned for 2017.

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

SPACE TROOPERS

BY ANNA HEINEY

NASA's Protective Services organization is tasked with protecting one-of-a-kind facilities and a world-class workforce at Kennedy Space Center. Ensuring the safety and security of this 144,000-acre, multi-user spaceport allows agency programs to stay focused on mission success.

It's a 24-hours-a-day, 365-days-a-year job that demands constant training for any number of real-life scenarios. In mid-November, eight members of Kennedy Space Center's Emergency Response Team took part in the 33rd annual SWAT Round-up International alongside 60 other teams from across the country and around the world.

"The entire week is very physically demanding and challenging. The teams competing in these events are all very good and some dedicate much of their training time specifically for this competition," explained Emergency Response Team Commander Bill Young of Chenega Security and Support Solutions.

Although the Kennedy team does train specifically for the competition in the weeks leading up to the five-day event, it spends the vast majority of the year focusing on protecting the spaceport.

"Our training time is spent on site preparing for responses to potential critical incidents that might occur here," Young said, pointing out that the greatest benefit to participating in the annual Round-up is the chance to meet and work with other teams.

"With the threats and challenges that exist for law enforcement today, it's short sighted to think any SWAT team can handle it all alone," Young said.

"The ability for our officers to effectively communicate and even integrate with other teams during a crisis is a force multiplier for our Protective Services, which benefits our center and the entire community."

Members of Kennedy Space Center's Emergency Response Team take off running during a challenge at the 33rd annual SWAT Round-up International in Orlando, Florida. Photo credit: NASA/Kim Shiflett

Prevailing Proposals

Technology

Trio earns Kennedy's first ever Science Innovation Fund awards

BY FRANK OCHOA-GONZALES

Getting to Mars is the goal. Figuring out how to get there requires innovative scientific research. Finding ways to fund this research often can prove difficult.

That is one reason why NASA Headquarters Office of the Chief Scientist invests in the Science Innovation Fund, or SIF. The fund capitalizes on innovative, exploratory, high-risk/high-return research undertakings aligned with NASA strategic objectives.

And with 116 proposals received from across the agency and sufficient funding for about one-third of those, many excellent proposals are unable to be funded.

This is the first time Kennedy Space Center employees submitted proposals and three selections made the cut. Those proposals were from Chemical Engineer Annie Meier, Dr. Paul Hintze and Dr. Mike Hogue.

Meier's proposal is "An In-Depth Study of Photocatalytic Charge Transport and Material Development Through Synthesis, Characterization and Computational Modeling for In Situ Resource Utilization and Fuel Production on Mars."

Meier says if the technology is successful, it will benefit human exploration of Mars by increasing the solar efficiency of carbon dioxide conversion via the Martian solar spectrum to produce fuel. This is a direct investment into in situ resource utilization, or ISRU, technology that will be required for the success of human spaceflight missions, cost reduction and long-duration space travel. Meier's team includes Dr. Mary Coan and Dr. Kathy Loftin.

"We have an opportunity to investigate and synthesize atomically thin materials that could potentially convert carbon dioxide into methane, using the solar spectrum and water vapor," Meier said. "That in itself is truly amazing."

The project could help convert Martian atmosphere, which is 95 percent carbon dioxide, into methane that could be used for fuel.

Hogue's proposal is "Dynamic Gas Flow Effects on the ESD of Aerospace Vehicle Surfaces."

This technology would develop a modified version of Paschen's law so that it will take into account the flow of gas between electrically charged electrode plates. This work would be applicable to aerospace vehicles traveling through the atmosphere where they are subjected to triboelectrically induced electrostatic charge build-up due to dust and ice crystal impingement and possible electrostatic discharge, or ESD. Triboelectrification is defined as triboelectric charging observed to put aircraft and space vehicles into corona when they fly through clouds containing ice or precipitation in either phase.

The theoretical model will be validated by wind tunnel experimentation at sub-sonic and super-sonic gas velocities to model aircraft and spacecraft moving through the atmosphere and has the potential to relax the launch criteria for triboelectric charging due to atmospheric dust or ice crystal impingement of spacecraft surfaces. This would save considerable money on launch costs if an abort could be avoided. The project would save millions of dollars that could be used to facilitate and utilize capabilities to deliver cargo and crew to space, and ultimately, Mars.

Dr. Mary Coan, Dr. Kathy Lofton and Chemical Engineer Annie Meier's project could help convert the Martian atmosphere, which is 95 percent carbon dioxide, into methane which could be used for fuel. Photo credit: NASA/Dan Casper

Dr. Mike Hogue hopes his proposal will relax the launch criteria for triboelectric charging due to atmospheric dust or ice crystal impingement of spacecraft surfaces. That would save considerable money on launch costs if an abort could be avoided. Photo credit: NASA/Dan Casper

Hintze's proposal is "Instrument for Solvent Extraction and Analysis of Extraterrestrial Bodies," or ISEE, using in situ resources.

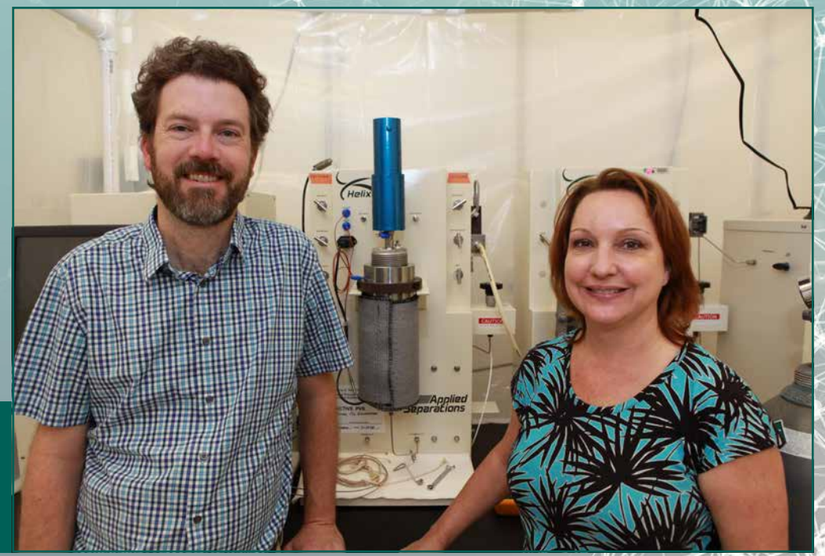
ISEE is a proposed novel, miniature system that enables solvent extraction and characterization of organic materials at extraterrestrial locations during robotic or human missions by using supercritical fluid extraction and chromatography. The goal of ISEE is to perform the chemical analysis with a solvent that was either captured in situ or recycled.

"This is a project I really believe in and I can't wait to get started," Hintze said. "Ultimately it will lead to an instrument that can go on other planets and detect organic material."

This project may enable scientists to analyze Martian samples for a variety of components including amino acids, which could provide information about potential life forms.

"I am very proud of Annie Meier, Dr. Paul Hintze, and Dr. Mike Hogue for selection of their innovative proposals," said Karen Thompson, Kennedy's chief technologist. "While a lot of work lies ahead, they should be lauded for their innovative ideas that were selected from a large group of proposals from many of NASA's best and brightest innovators."

NASA aims to promote breakthroughs in science that highlight innovation in the current state of the art; strategic planning; collaborations across disciplines; flexibility to foster new talent; building R&D capability needed to fulfill NASA's mission; and creativity across NASA's workforce.



Dr. Paul Hintze and Dr. Kathy Lofton hope their project will enable scientists to analyze Martian samples for a variety of components including amino acids which could provide information about potential life forms. Photo credit: NASA/Dan Casper

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Space Flight Awareness

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NW-2015-01-001-JSC

Engineers work with the SAGE III instrument inside the Space Station Processing Facility at Kennedy Space Center to begin processing for its launch next year to the International Space Station. Once at the station, NASA's Stratospheric Aerosol and Gas Experiment III instrument will take long-term measurements of ozone, aerosols and other trace gasses to help scientists better understand how to monitor and protect the Earth's atmosphere. SAGE III will fly to the station next year aboard a SpaceX Falcon 9 rocket.

Photo credit: NASA/Charles Babir

For more, go to http://go.nasa.gov/1XCaUH2

NEW DAWN OF SPACEFLIGHT

Crew Access Tower construction progresses at Cape Canaveral

An artist's concept of Space Launch Complex 41 on launch day showing the Crew Access Tower in place beside a Boeing CST-100 Starliner spacecraft and United Launch Alliance Atlas V rocket. Image credit: Boeing

BY STEVEN SICELOFF

It took only 35 days to build the main column of a new fixture to the skyline along the Florida Space Coast. The 200-foot-tall Crew Access Tower at Cape Canaveral Air Force Station in Florida will meet the unique needs of astronauts and ground crews at Space Launch Complex 41, or SLC-41. This is where Boeing will launch its CST-100 Starliner spacecraft on Atlas V rockets operated by United Launch Alliance, also known as ULA.

"We spent a lot of time with conceptual designs and with the human elements, which is very important for a project of this nature," said Howard Biegler, ULA's Launch Operations lead for Human Launch Services. "Building a structure is one thing, but building it so that it's useful, that it provides a safe environment for the people who are going to be called to use this system is the hard part."

The structure features wider, more open areas than NASA's previous crew access towers, providing more room and comfort for astronauts who will walk around the area in pressure suits and possibly wearing helmets, and in emergency cases, walk through walls of water from fire suppression sprinklers. An escape system for the ground support teams and flight crews will be added to quickly move people from the top of the tower to the safety of an evacuation vehicle in less than a minute.

The tower location is unique, as well. Since 1968, all astronauts launched from the United States have flown exclusively from Launch Pads 39A and B at Kennedy Space Center.

Construction at the pad began in September when the first of seven steel tiers was trucked from four miles away where it was built and then placed atop a strengthened concrete foundation at SLC-41.

Built with many of the features already in place such as stairways, cable trays and blast shielding, each tier was designed to fit atop the other perfectly to reduce construction time at the pad. That's because ULA kept the pad operational so it could continue to launch Atlas V missions in between stages of tower construction.

"We have certainly changed the landscape out here," Biegler said. "The day the first tier physically made contact with the concrete and was bolted up brought a new level of reality to the project."

More work is ahead to complete the tower, but the main column stands in place as a herald for the next generation of human spaceflight in America. Steel sections branching off the main column will be in place by mid-January, then the tower will be fitted with elevators, data lines and other elements. The tower's steel frame will weigh about 966,000 pounds when it's completed in fall 2016.

In late October, the structure's crew access arm was connected to the White Room, which will serve as the final corridor astronauts will pass through as they enter the Starliner spacecraft standing atop the Atlas V. The two components will be tested together extensively off-site before they are trucked to the launch complex and installed next summer.

Boeing anticipates launching the first flight test of its Starliner spacecraft carrying astronauts in 2017, but will use the tower before that time in the preparation for an earlier flight test without a crew aboard.

"It takes a lot of people working hard together to get any spacecraft into orbit successfully, and that's doubly true for a new spacecraft being built for humans," said Mike Burghardt, director of Launch Segment Integration for Boeing's Commercial Crew Program. "The Starliner will feature modern, high reliability components to significantly increase crew safety and we back that up with robust launch system, including this Crew Access Tower."

All the work is adding to the feeling that a new dawn of spaceflight is nearing as NASA's Commercial Crew Program and its partners Boeing and SpaceX continue development on systems that will carry up to four astronauts at a time to the International Space Station. With commercial spacecraft transportation, NASA plans to add an additional crew member to the station, effectively doubling the crew time dedicated to research on the orbiting laboratory.

While Boeing and SpaceX focus on transportation opportunities in low-Earth orbit, NASA is moving ahead with its Space Launch System and Orion spacecraft that will take off from Kennedy's Launch Pad 39B to carry out deep-space exploration missions that will advance the agency's journey to Mars.

Watch the time-lapse video as workers stack the elements for the main column of the Crew Access Tower at Space Launch Complex 41. The tower will serve flight crews and support teams for missions by Boeing's CST-100 Starliner spacecraft.

https://www.youtube.com/watch?v=hr1XTLC9uqw

SUPPLY RUN

Cygnus sealed inside fairing

BY STEVEN SICELOFF

The enhanced Cygnus spacecraft and more than 7,300 pounds of cargo have been enclosed inside a payload fairing at Kennedy Space Center as processing moves ahead on schedule for a Dec. 3 launch. The Orbital ATK Cygnus will be moved to Space Launch Complex 41 and lifted to the top of a waiting United Launch Alliance Atlas V rocket.

The spacecraft, which will carry no people, is to lift off aboard the Atlas V to take equipment, experiments and supplies to the International Space Station for use by the residents there including yearlong-crew member astronaut Scott Kelly.

Speaking to the news media in November, Orbital ATK's Dan Tani — a former astronaut who served as a station resident — said a new round of cargo always brings excitement: "It's a real morale boost. It's like coming home from the store and unpacking the trunk full of the things you bought. A lot of stuff you didn't know you needed along with a lot of things like notes from home and other items that are really meaningful."

The enhanced Cygnus can carry about 25 percent more mass than its predecessor and features upgraded Ultraflex solar arrays that unfurl like a fan into a circle and are lighter than the previous models. For NASA, the increased capacity brings the obvious benefit of taking more to the station at once, ranging from daily supplies of food and clothing for the station residents to new experiments so astronauts can continue to use the space-based laboratory to the benefit of all on the Earth. For the astronauts, the new round of cargo brings excitement.

Photo credit: NASA/Demetrius Gerondidakis

FEEL THE FORCE

Crew Dragon propulsion system completes development testing

BY STEVEN SICELOFF

The propulsion system SpaceX would use to power its Crew Dragon out of danger has been test-fired 27 times as the company refines the design for the demands of operational missions carrying astronauts to the International Space Station for NASA's Commercial Crew Program. SpaceX evaluated the system utilizing various thrust cycles on a test stand at its McGregor, Texas, rocket development facility.

Named SuperDracos, the engines are arranged in four pairs — SpaceX calls them 'jetpacks' — integrated around the outside of the Crew Dragon spacecraft. Firing all at once, the eight engines produce 120,000 pounds of thrust — enough power to accelerate a Crew Dragon from zero to 100 mph in 1.2 seconds. In the unlikely event of an emergency, that power means the ability to lift the crew a safe distance off the launch pad or far away from a booster failing on the way to orbit. That capability was demonstrated earlier this year in a pad abort test that confirmed the SuperDraco design in a flight-like condition.

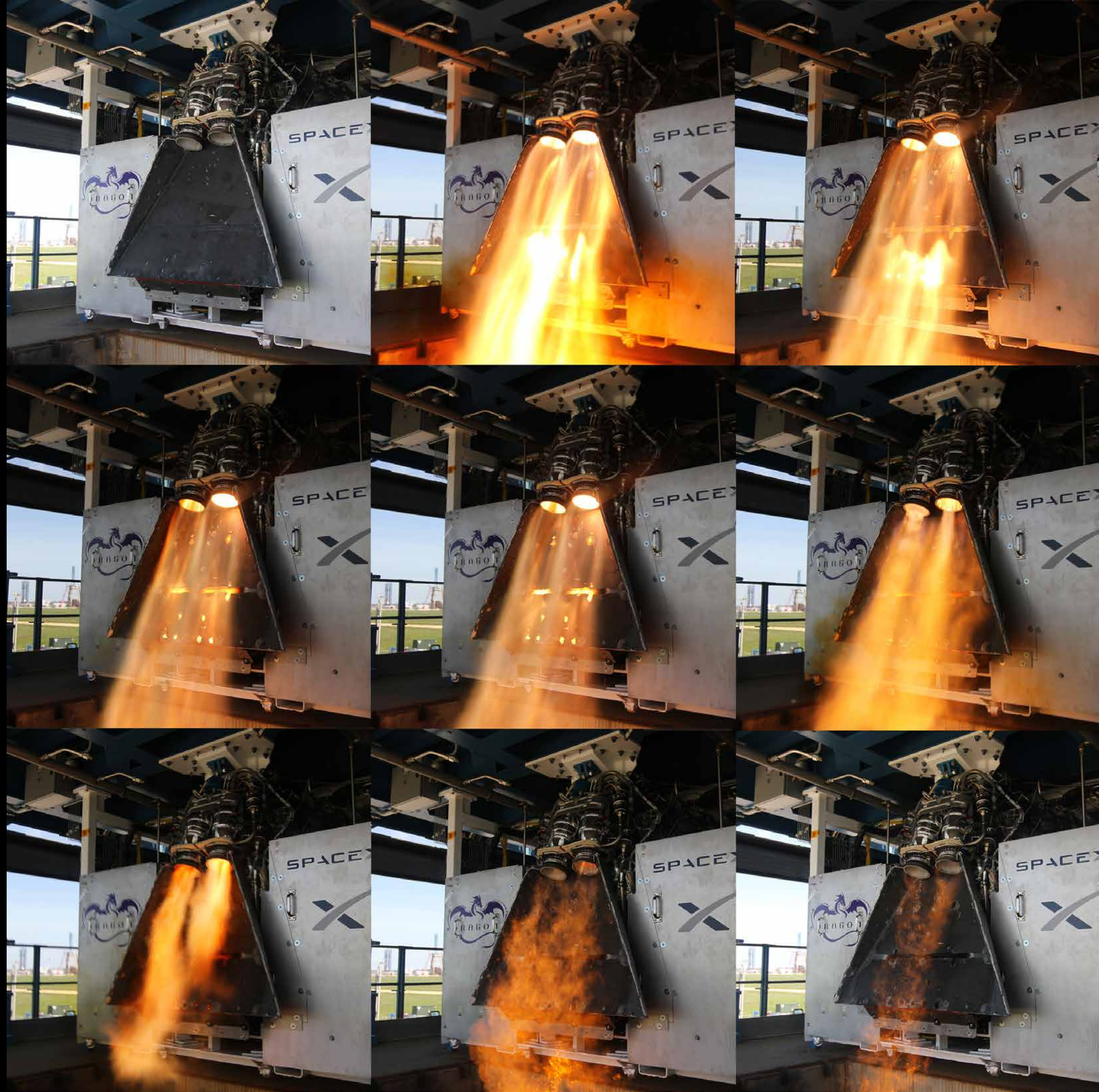
A normal launch of the Crew Dragon atop a Falcon 9 rocket would not offer the SuperDracos anything to do during the mission since their only responsibility is to fire in an emergency to rescue the crew onboard. Eventually, SpaceX plans to use the SuperDracos in the place of a parachute during landing.

They use hypergolic propellants common in spacecraft thruster systems because the propellants ignite as soon as they contact each other. The engines are noteworthy for a number of reasons, including that they are built using 3-D printing methods instead of machining them from larger pieces.

After the development cycle, the propulsion system and SuperDracos will continue evaluations at the company's test stand to qualify them for use on operational missions.

SpaceX and Boeing are developing a new generation of American-made, human-rated transportation systems capable of taking astronauts to the space station in partnership with NASA. The Crew Dragon and Boeing's CST-100 Starliner will carry up to four NASA astronauts at a time, which ultimately adds another crew member to the space station and will allow twice as much time for astronauts to conduct research aboard the one-of-a-kind laboratory.

View the test at http://go.nasa.gov/1XCEH2o



Photos courtesy of SpaceX

Hidden Benefits

Dr. Luz M. Calle, the technical lead for Kennedy Space Center's Corrosion Technology Laboratory, checks out sample tiles at the Beachside Corrosion Test Facility. Photo credit: NASA

Smart coating technology earns 'Create the Future Design' award

BY LINDA HERRIDGE

Corrosion is a real concern at Kennedy Space Center. Exposure to humidity, salt, ultraviolet light and exhaust from rocket launches can start the condition in facilities and metal structures. Of special concern are the launch pad and ground support equipment currently being prepared for the agency's Space Launch System and Orion spacecraft.

Scientists at Kennedy, including Dr. Luz M. Calle technical lead for the center's Corrosion Technology Laboratory in the Research and Technology Programs Directorate, have developed an environmentally friendly smart coating that could be used in the future to detect and stop corrosion in metal.

This innovative technology, called "Smart Coating for Corrosion Detection and Protection," was recognized by NASA Tech Briefs magazine's "Create the Future Design" contest with the top award in the automotive and transportation category.

Calle accepted the award on behalf of the team during a ceremony Nov. 6 in New York City.

"We are known for launching rockets, but we are not thought of as a place where interesting technologies like smart coatings are being developed," Calle said. "It's good to be recognized by people outside of Kennedy Space Center in a worldwide contest.

"Corrosion of metals is a very serious and costly problem worldwide," Calle said. "But, here at Kennedy Space Center, we have one of the most corrosive environments in the world, certainly the most corrosive in North America.

"The natural environment at Kennedy is extremely corrosive due to the combination of ocean salt spray, heat, humidity and sunlight. With the introduction of the space shuttle in 1981, the already highly corrosive conditions at the launch pads became even more severe with the acidic exhaust from the shuttle's solid rocket boosters," Calle said. Calle explained that one way to protect metals from corrosion is by applying a coating to them. This creates a barrier between the metal and the environment. But when the coating is damaged, its ability to protect against corrosion stops.

Another way to prevent corrosion is to add corrosion inhibitors to the coating. But, Calle said, there are several problems with current inhibitors. Though very effective, many of them are harmful to humans and the environment. Top on that list is hexavalent chromium, widely used in the aerospace industry for protection of aluminum.

Calle said finding environmentally friendly corrosion inhibitors that don't interact with the coating is challenging. The coating doesn't adhere as well or destroys the inhibitor, and sometimes problems can arise if a lot of inhibitor has been added to the coating.

Calle said the idea for smart coating technology was born in 2004 and work to develop it has continued throughout the years. Corrosion inhibitors can be packaged inside tiny micro capsules or micro containers, developed in the Corrosion Technology Laboratory at the Operations and Checkout Building. The containers are porous and less than one-tenth the size of the diameter of a human hair.

The micro capsules are added to the coating, and they remain dormant until corrosion begins underneath the coating. That's where the "smart" portion of the technology kicks in. The shell of the micro capsules are designed to break open and deploy the corrosion inhibitor.

"We call them feedback active micro containers, because they respond to what is happening around them," Calle said. "They're not passive. They just know what to do. Basically, the shells break down and deliver the corrosion inhibitor, and then they disintegrate."

Another type of delivery system being developed is a micro container that is porous. The corrosion inhibitor is trapped in the pores, similar to water being trapped in a sponge. When the corrosion starts, the inhibitor is released to do its work.

An issue at launch pad sites has been the problem of corrosion to large bolts. On the surface they look good, but the corrosion is taking place inside the bolt. Calle's team is working on encapsulating color-changing corrosion indicators in coatings.

"If we have a coating with micro capsules that contain a corrosion indicator that changes color when corrosion is present on the inside, then it will be evident from the outside that there is a problem," Calle said.

Smart coating samples are being tested at the Beachside Corrosion Test Facility, which is near the launch pads.

"We are working with several industry partners in the coatings and automotive industries because we are interested in transferring this technology so it can be available to everyone," Calle said.

The "Create the Future" design contest was launched in 2002 by the publishers of NASA Tech Briefs magazine to help stimulate and reward engineering innovation. The annual event has attracted more than 10,000 product design ideas from engineers, entrepreneurs and students worldwide. This year's competition attracted 1,150 entries in seven different categories from more than 60 countries.

Sponsors of the NASA Tech Briefs magazine's "Create the Future Design" contest are with Dr. Luz M. Calle, top winner in the automotive and transportation category for the innovative technology "Smart Coating for Corrosion Detection and Protection." From left, are Sumit Awasthi, Global E-Commerce Channel manager; Calle; Dr. H.C. Svante Littmarck, COMSOL Group chief executive officer; and Marilyn Cooper, Mouser Electronics corporate supplier manager. Photo credit: Courtesy of Ellen Dubin Photography

Santa Support

Kennedy counts down to Santa's annual toy delivery mission

BY BOB GRANATH

Kennedy Space Center is counting down to support Santa Claus during his annual mission to deliver toys and other presents to children around the world. As always, the jolly old fellow will have the opportunity to take advantage of the agency's latest advances in technology.

Claus will have access to the most recent findings on the amounts of moisture and frost in the Earth's surface. NASA's Soil Moisture Active Passive, or SMAP, satellite, is providing the latest measurements of the Earth's soil moisture distribution and freeze/thaw rates. This global data could be valuable in helping Claus determine the best places to land his sleigh.

Additionally, Claus and his reindeer will be given the opportunity to use Kennedy's Shuttle Landing Facility if a rest stop is needed during their long Christmas Eve trip. During the past year, NASA signed a 30-year property agreement with Space Florida for the operations and management of the facility. Now that Kennedy is a 21st century multi-user spaceport, a variety of commercial and government partners may use the 3-mile long runway.

If he does choose to touch down at the Shuttle Landing Facility, Claus' reindeer will feel right at home at the Merritt Island National Wildlife Refuge. Alongside the many high-tech facilities at the Florida spaceport, Kennedy employees work in an animal sanctuary that is home to hundreds of wildlife species. The diverse, 140,000-acre landscape provides a habitat for many varieties of animals, including alligators, manatees and deer.

Claus has one extraterrestrial destination this year — the International Space Station. The crew recently celebrated the 15th anniversary of permanent occupancy of the orbiting laboratory. The first expedition crew docked with the station Nov. 2, 2000, and began activation of the station and scientific research that has continued nonstop.

In addition to St. Nick's Christmas Eve delivery, crews aboard the ISS received supplies in April when a SpaceX Falcon 9 rocket launched from Cape Canaveral Air Force Station on its sixth commercial resupply services mission. The SpaceX Dragon capsule brought up 4,300 pounds of scientific experiments, technology demonstrations and supplies.

On Dec. 3, an Orbital ATK Cygnus spacecraft is scheduled to lift off with more than 7,000 pounds of additional research equipment to support science investigations by the station crew.

Soon, astronauts can join Claus by flying from U.S. soil to the space station aboard new spacecraft as part of NASA's Commercial Crew Program. The effort is a partnership that will include Boeing's CST-100 Starliner and SpaceX Crew Dragon taking astronauts to the orbiting laboratory.

Should Claus wish to visit future pioneers living and working on Mars, recent findings should aid St. Nick when he visits the Red Planet. Earlier this year, NASA's Mars Reconnaissance Orbiter provided the strongest evidence yet that liquid water flows intermittently on present-day Mars. Dark streaks appear to ebb and flow in numerous locations when temperatures rise above 10 degrees below zero Fahrenheit and disappear at colder times.

As future explorers reach farther into the solar system, Claus may want to pay them a visit. Launched from the Cape on Jan. 19, 2006, NASA's New Horizons spacecraft provided the first close-up observations of Pluto on July 14 of this year. While human exploration may be years away, it gives the jolly old fellow time to map out his gift-giving strategy no matter where astronauts venture into the cosmos.

NORAD Tracks Santa

for the 60th Year

BY AMANDA GRIFFIN

For the past 60 years, children around the world have been able to follow Santa Claus as he treks across the globe every Christmas Eve, courtesy of NORAD — the North American Aerospace Defense Command. And it all started with a misprinted telephone number in a Colorado newspaper.

On Dec. 24, 1955, a Sears department store placed an advertisement in a Colorado Springs newspaper that included a telephone number children could call in order to speak with Santa Claus. But, the number was printed incorrectly.

The published telephone number actually was that of the U.S. Air Force command center of NORAD's predecessor, the Continental Air Defense Command based in Colorado Springs. Specifically, it was a red phone on the desk of Col. Harry Shoup, commander of the Combat Alert Center. Ordinarily, only a general at the Pentagon would be calling.

Additionally, this was the 1950s, and it was in the midst of the Cold War. When the phone rang, Shoup answered expecting a national or even a global crisis. Instead, the voice was that of a small child asking, "Is this Santa Claus?"

He could have just hung up, but Shoup continued to speak with the little one asking, "Have you been good this year?"

After talking to that first young caller, Shoup spoke with his mother who told him about the ad in the local newspaper. He checked and, sure enough, the number printed was off by one digit and was that of the red phone on his desk.

Throughout that memorable Christmas Eve, Shoup and airmen on his staff fielded many more calls from children. Each time a young caller reached them, Shoup's team checked the radar and reported the current location of St. Nick.

A Christmas Eve tradition was born.

In 1958, NORAD was formed, and aside from their important task of aerospace warning and control, along with maritime warning in the defense of North America, they also took on tracking the magical journey Santa Claus makes every Christmas Eve.

Today, NORAD relies on volunteers to make the program possible. Now known as the "NORAD Tracks Santa" program, the organization tracks Claus as he leaves the North Pole and delivers presents to children around the world.

Through satellite systems, high-powered radar, jet fighters and special "Santa Cameras," NORAD can accurately pinpoint the jolly old fellow at any given moment on Dec. 24 — even when he is stopping by the International Space Station to drop off a few gifts for the deserving astronauts and cosmonauts.

Starting Dec. 1, 2015, anyone may access the NORAD website for a countdown calendar, games and other fun activities for kids at www.noradsanta.org.

U.S. Air Force Col. Harry Shoup came to be known as NORAD's "Santa Colonel." Photo credit: U.S. Air Force/NORAD

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A Century of Flight

Commercial travel opens unlimited opportunities

BY BOB GRANATH

On a brisk day more than a century ago, what started as a venture between two brothers changed the world forever. On Dec. 17, 1903, Orville and Wilbur Wright opened the world of air travel with their first flight at Kitty Hawk, North Carolina. In 10 short years, commercial aviation became a reality. Fast forward another 50 years and humans not only were flying in the air, but also in space. After another half-century of spaceflight, NASA and its industry partners now are on the verge of inaugurating the Commercial Crew Program, ferrying astronauts to the International Space Station, once again launching humans from American soil.

Individual inventors such as the Wright Brothers were the original investors in the early development of aviation. They were successful because of their willingness to challenge a belief held by many that human flight was impossible.

"If we worked on the assumption that what is accepted as true really is true, then there would be little hope for advance," said Orville Wright.

Various government agencies, such as the military, soon showed interest. Once it became cost-effective to carry paying customers, commercial aviation also took off — just as commercial space is today.

Tony Jannus, right, pilots a flying boat in a flight across Tampa Bay on Jan. 1, 1914. The paying passenger, Abram Pheil, left, flew from St. Petersburg to Tampa, Florida, in 23 minutes.
Photo credit: Courtesy of State Archives of Florida

First Commercial Flight

The first paying fixed-wing passenger checked his bag on Jan. 1, 1914. Pilot Tony Jannus flew his customer, Abram Pheil, from St. Petersburg to Tampa, Florida. The trip across the 21 miles of Tampa Bay took 23 minutes.

Jannus auctioned off the privilege of traveling on this inaugural flight with prospective passengers bidding large amounts of money for the one seat. Pheil, a former mayor of St. Petersburg, was the winner paying $400 ($5,000 in today's currency) for the privilege.

On that New Year's Day in 1914, one person flew one commercial flight. A century later, the International Air Transportation Association estimates 8 million passengers fly world-wide on almost 100,000 flights each day. That equates to nearly 3 billion air travelers every year.

One of the first commercial uses of aviation was delivering mail. The first experimental American airmail delivery was made on Sept. 23, 1911, under the authority of the U.S. Post Office Department. The service was intermittent until domestic U.S. Air Mail was formally established by the Post Office Department on May 15, 1918. At that time the first special Air Mail stamps were issued.

The U.S. government began to take a serious role in the development of the aviation age with the formation of the National Advisory Committee for Aeronautics, or the NACA, on March 3, 1915. The NACA was established to "undertake, promote, and institutionalize aeronautical research."

Part of the U.S. government's early interest in aviation centered on possible military applications. In fact, aviation proved to be a viable industry with the onset of World War I.

In 1914, the U.S. Census Bureau listed only 16 aircraft companies. Their collective output was 49 aircraft.

By the end of the World War I, 175,000 people were employed at 300 airplane manufacturing plants in the United States. By the time of the armistice on Nov. 11, 1918, the new industry produced 13,844 aircraft.

Airports Begin Dotting America

Along with a flourish of commercial airlines, airfields were springing up across America. In 1923, Atlanta alderman William Hartsfield was assigned to find a place for a new airport. The goal was to convince the U.S. Post Office Department to give the Georgia capital one of the contracts for a lucrative air mail route.

Candler Field in the Atlanta suburb of Hapeville, Georgia, was originally an auto racetrack similar to the one at Indianapolis, Indiana. Through Hartsfield's efforts, barnstormers and former World War I aviators began flying in and out of Atlanta in the early 1920s. On Sept. 15, 1926, Atlanta aviation history was made when the first air mail flight took off from the city.

Hartsfield went on to serve as Atlanta's mayor and the airport is now named for him and Mayor Maynard Jackson. During the late 1970s, Jackson helped lead the effort to build a modern airport terminal, which opened in 1980. According to the Airports Council International's "World Airport Traffic Report," the Hartsfield-Jackson Atlanta International Airport is the busiest in the world with more than 96 million people passing through the hub each year.

First Modern Passenger Airliners

The Boeing 247 is considered the first modern passenger airliner. Introduced in 1933, the aircraft was similar to a low-wing, twin-engine military bomber with retractable landing gear. Put into service by United Air Lines, it could accommodate 10 passengers and travel at 155 mph.

At about the same time, the Douglas Aircraft Co. DC-3 became a popular airliner due to its cruising speed of 207 mph and a range of 1,500 miles, revolutionizing air transport. When converted to the military version, designated the C-47, it was widely used in World War II.

One of the first commercial uses of aviation was delivery of mail. The first experimental American airmail delivery was made on Sept. 23, 1911. The service was formally established by the Post Office Department on May 15, 1918. As a new class of postal delivery, the first of Air Mail stamps were issued. The 24 cent stamp depicted a Curtis Jenny Biplane frequently used for transporting air mail.
Photo credit: Courtesy of U.S. Post Office Department

The DC-3 is often viewed as the aircraft that revolutionized passenger air transport. The military version was designated the C-47, affectionately known as the Gooney Bird. It was used during World War II to drop paratroopers into France on D-Day and flying supplies "over the hump," better known as the Himalayas.
Photo credit: Courtesy of U.S. Army Air Force

Prior to 1940, passenger aircraft only flew as high as 10,000 feet, due to the reduced levels of oxygen at higher altitudes. The breakthrough allowing people to fly in pressurized comfort came with the Boeing 307 Stratoliner which began service July 8, 1940. The 33-seat aircraft flew as high as 20,000 feet and could travel at 200 mph.
Photo credit: Courtesy of State Library and Archives of Florida

Toward the end of World War II, jets ushered in a new age in aviation. At the Ames Aeronautical Laboratory, Moffett Field, California, NACA test pilot Lawrence Clousing climbs into his Lockheed P-80 aircraft for a test flight. Clousing set a speed record of 658 mph aboard a P-80 in 1948. Photo credit: NACA

Derived from the passenger jet, the Boeing 707, the E-3 Sentry is an airborne warning and control system aircraft that provides all-weather surveillance, command, control and communications needed by commanders of U.S. and NATO air defense forces. Photo credit: U.S. Air Force photo

The Shuttle Carrier Aircraft transports the space shuttle Discovery from Kennedy Space Center to the Smithsonian's National Air and Space Museum Steven F. Udvar-Hazy Center on April 17, 2012. For more than 30 years, the modified 747 was used to transport space shuttles between landing sites in California and Florida. Photo credit: NASA/Lorne Mathre

During the 1930s and 1940s, passenger aviation made important strides, but there was a significant drawback. The 247 and the DC-3 could only fly as high as 10,000 feet, due to the reduced levels of oxygen at higher altitudes. Flying higher would allow airliners to rise above air turbulence and storms prevalent at lower levels.

The breakthrough came with the Boeing 307 Stratoliner, which began service in 1940 with TWA — Trans World Airlines. Derived from the B-17 bomber, it was the first aircraft with a pressurized cabin. The 33-seat Stratoliner flew as high as 20,000 feet and could travel at 200 mph.

During the Second World War, the NACA also made numerous crucial contributions sometimes referred to as "the force behind our air supremacy." Most notably, the agency played key roles in producing innovative superchargers, providing more efficient engines for high altitude bombers and improved technology for wings.

Following the war, commercial aviation grew at a rapid pace with airlines regularly transporting passengers and cargo. This expansion was aided by wartime technology development such as that of heavy B-29 bomber airframes. The aviation industry also began transitioning from propeller aircraft to jets.

The first commercial jet airliner to fly was the British de Havilland Comet first flown in 1949. During the late 1950s, Boeing's 707 and the Douglas DC-8 offered comfort and safety leading to extensive commercial jet air travel in the United States.

Dawn of the Space Age

At about that same time, the space age began on Oct. 4, 1957, with the launch of the Sputnik satellite by the Soviet Union. An American satellite, Explorer 1, soon followed, with plans for sending humans into space in the near future.

In the midst of these advances, President Dwight Eisenhower directed the NACA to be reorganized on Oct. 1, 1958, forming NASA — the National Aeronautics and Space Administration.

"(There are) many aspects of space and space technology," he said, "which can be helpful to all people as the United States proceeds with its peaceful program in space science and exploration."

As was the case with early aviation, American industry partnered with the government to advance spaceflight technology. Many of the same aerospace corporations that took the nation to the skies began supporting the new space agency's efforts to explore beyond the atmosphere. Contractors developed the launch vehicles and satellites to study the Earth, probes to explore beyond low-Earth orbit and spacecraft to take the first humans into the new frontier.

Airlines Double Down

During 1969, the year astronauts first walked on the moon, America's aerospace industry debuted wide-body passenger airliners such as the Boeing 747.

Pan American Airways was the first to purchase and fly the 747 jumbo jet. It had two aisles and an upper deck over the front section of the fuselage. With a capacity of 450 passengers, it doubled the size of other Boeing jets and was 80 percent larger than any other jetliner up to that time.

McDonnell Douglas soon answered with their DC-10 in 1970, and Lockheed entered the wide-body market with the L-1011. Both had three engines, one under each wing and one on the tail, and each had a seating capacity of about 250.

In addition to flying more passengers in enhanced comfort, in the late 1960s airlines began to focus on increased speed. The NACA played a key role proving that it was possible to fly faster than the speed of sound — about 768 mph. In 1947, the Bell X-1 had broken the sound barrier, but there still were obstacles for a commercial supersonic transport.

The Soviet Union successfully developed and tested the supersonic Tupolev 144 in late 1968. A consortium of West European aerospace firms flew the Concorde in early 1969 and eventually produced a number of those fast airlines for commercial use. American efforts to produce supersonic transports stalled in 1971. The primary concern was the sonic boom produced by these aircraft.

A sonic boom occurs when an object travels through the atmosphere faster than the speed of sound. It creates shock waves generating enormous energy sounding like an explosion.

Developments of commercial aviation have had a world-wide financial impact. According to the website of the travel publication "Jet Set Times," the global aviation industry annually supports 57 million jobs and $2.2 trillion in economic activity. In a 12 month period, 50 million tons of cargo are flown by air transport aircraft, accounting for $6 trillion in goods equating to 35 percent of all products traded internationally.

Rise of Commercial Spaceflight

Early developments in aviation were dominated by individuals working privately. This later was followed by governments and industry. However, in the first eras of space exploration, costs and risks were borne solely by government agencies, both military and civilian.

But now that NASA and other agencies have greased the skids, oopportunities for space tourism also are on the verge of becoming a reality for recreational or business purposes.

In the late 1990s, MirCorp was responsible for operation of the Russian space station Mir, and began seeking tourists willing to pay for a trip into space. American businessman Dennis Tito, a former scientist at the Jet Propulsion Laboratory in California, entered into an agreement with MirCorp and U.S.-based Space Adventures Ltd.

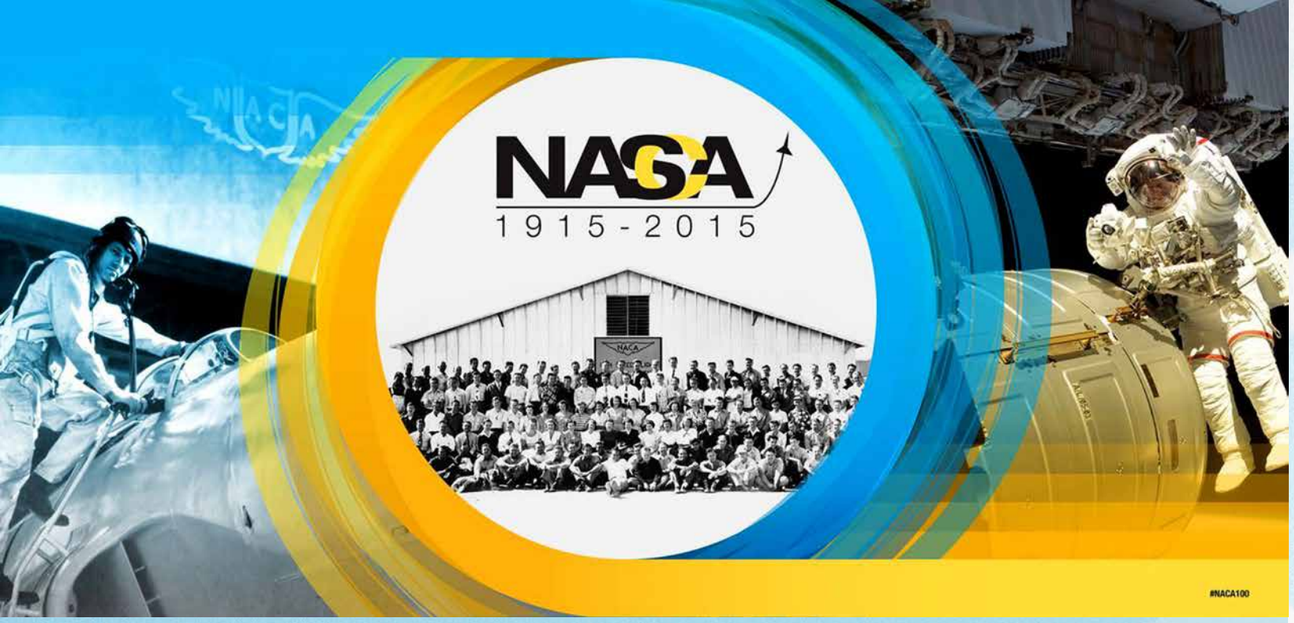
Tito was the first "fee-paying" space tourist visiting the International Space Station in April 2001, staying for seven days.

Established in May 1996, the Ansari X Prize was a competition offering $10 million to the first non-government

On March 3, 2013, Expedition 34 crew members aboard the International Space Station use a robotic arm to capture a SpaceX Dragon capsule delivering supplies. NASA's commercial space program has fostered a successful partnership with American companies to resupply the station through the Commercial Resupply Services program. In the near future, a similar Dragon spacecraft will launch astronauts to low-Earth orbit as part of the Commercial Crew Program. Photo credit: NASA

Professor Mark Drela, center, chief engineer of a Massachusetts Institute of Technology aircraft design team, helps undergraduate students Nina Siu, left, and Mike Lieu position a model of the D8 "double bubble" in a wind tunnel at MIT. The team, which includes Aurora Flight Sciences and Pratt & Whitney, designed the concept. The D8 series aircraft would be used for domestic flights and is designed to fly at Mach 0.74 carrying 180 passengers 3,000 nautical miles in a coach cabin roomier than that of a Boeing 737-800. Photo credit: NASA/MIT

An artist concept of the Boeing CST-100 Starliner depicts it in low-Earth orbit above Florida. The spacecraft will launch from Cape Canaveral Air Force Station atop United Launch Alliance Atlas V rockets as part of NASA's Commercial Crew Program. Image credit: Boeing



The 100th Anniversary NACA/NASA logo. Image credit: NASA

organization to launch a reusable, piloted vehicle into space twice within two weeks. Designed to encourage development of low-cost spaceflight, the concept was modeled after early 20th-century aviation prizes.

On June 21, 2004, SpaceShipOne made the first privately funded human spaceflight. The spacecraft was developed by Mojave Aerospace Ventures, a joint enterprise between Scaled Composites, an aviation company founded by test pilot Burt Rutan and Microsoft founder Paul Allen. The second flight was Sept. 29, 2004. Five days later, SpaceShipOne's developers won the X Prize by reaching 62 miles in altitude twice in a two-week period. The 62-mile mark is recognized by the Fédération Aéronautique Internationale (International Aeronautical Federation) as the threshold of space.

The success of SpaceShipOne led to Virgin Galactic forming a company designed to provide suborbital spaceflights aboard SpaceShipTwo to launch space tourists, suborbital flights for space science missions and orbital launches of small satellites.

NASA's commercial space program has fostered a successful partnership between the agency and two American companies to resupply the International Space Station. Following the end of the Space Shuttle Program, SpaceX and Orbital ATK began providing resupply spacecraft launching cargo and supplies to the space station through the Commercial Resupply Services Program.

In the near future, commercial spaceflight not only will include supplies, but also humans.

"American companies are developing the new systems in which astronauts soon will travel from the United States to low-Earth orbit," said NASA Administrator Charlie Bolden during remarks at Kennedy on Feb. 2, 2015.

In September 2014, the agency announced the selection of Boeing and SpaceX to transport U.S. crews to and from the International Space Station using their CST-100 Starliner and Crew Dragon spacecraft, respectively.

The goal is for U.S. missions to the station to end the nation's sole reliance on Russia in 2017, and allow the station's current crew of six to grow, enabling more research aboard the unique microgravity laboratory.

By allowing industry to provide "taxi" services to the space station, NASA now can concentrate on exploration to distant destinations such as a near-Earth asteroid and Mars.

At the same time, the agency also is teaming with industry and academia in developing future aircraft that conserve fuel, lower emissions and reduce noise.

Since the sound barrier first was broken in 1947, aviation experts have sought ways to limit the jarring effects of the sonic booms. One of NASA's primary aeronautical goals is to work with the aerospace industry to develop aircraft that achieve a low or quiet enough boom that a current federal ruling prohibiting supersonic flight over land might be lifted.

Over the past century, pioneering inventors and entrepreneurs in aerospace have been driven by inspiration and supported by those who backed their efforts to go faster, higher and farther.

"We were lucky enough to grow up in an environment where there was always much encouragement to children to pursue intellectual interests," said Orville Wright. "We investigated whatever aroused curiosity."

Today, NASA is trying to instill these same values with the vision to reach new heights, reveal the unknown, while benefiting all humankind.

Sweet Ideas

Pioneers used unprecedented methods to early commercial aviation

In front of the first hangar at Candler Field, which would become the Hartsfield-Jackson Atlanta International Airport, Doug Davis' fleet of Waco-9 bi-planes make up the Baby Ruth Flying Circus. Photo credit: Courtesy of National Waco Club

BY BOB GRANATH

Some of the pioneering entrepreneurs of aviation found novel approaches to making use of the new technology.

In the 1920s, Atlanta opened an airport seeking to secure a lucrative contract for one of the new air mail routes. One of the first to open for business at the new air field was Georgia native Doug Davis. The World War I aviator and barnstormer started the Douglas Davis Flying Service with the first airport hangar at what then was called Candler Field. Today it is the Hartsfield-Jackson Atlanta International Airport.

In 1924, Davis was selected by the Curtis Candy Co. to form the Baby Ruth Flying Circus to advertise the new chocolate bar. The plan was to fly over large crowds during outdoor events and drop hundreds of samples attached to tiny parachutes. However, this approach required an assistant to pitch the candy bars overboard while Davis flew the airplane.

One of those Davis enlisted was an 11-year-old boy who loved aviation and frequently dropped by the new Atlanta airport to talk to some of the pilots who worked there.

That youngster was my father, Buster Granath.

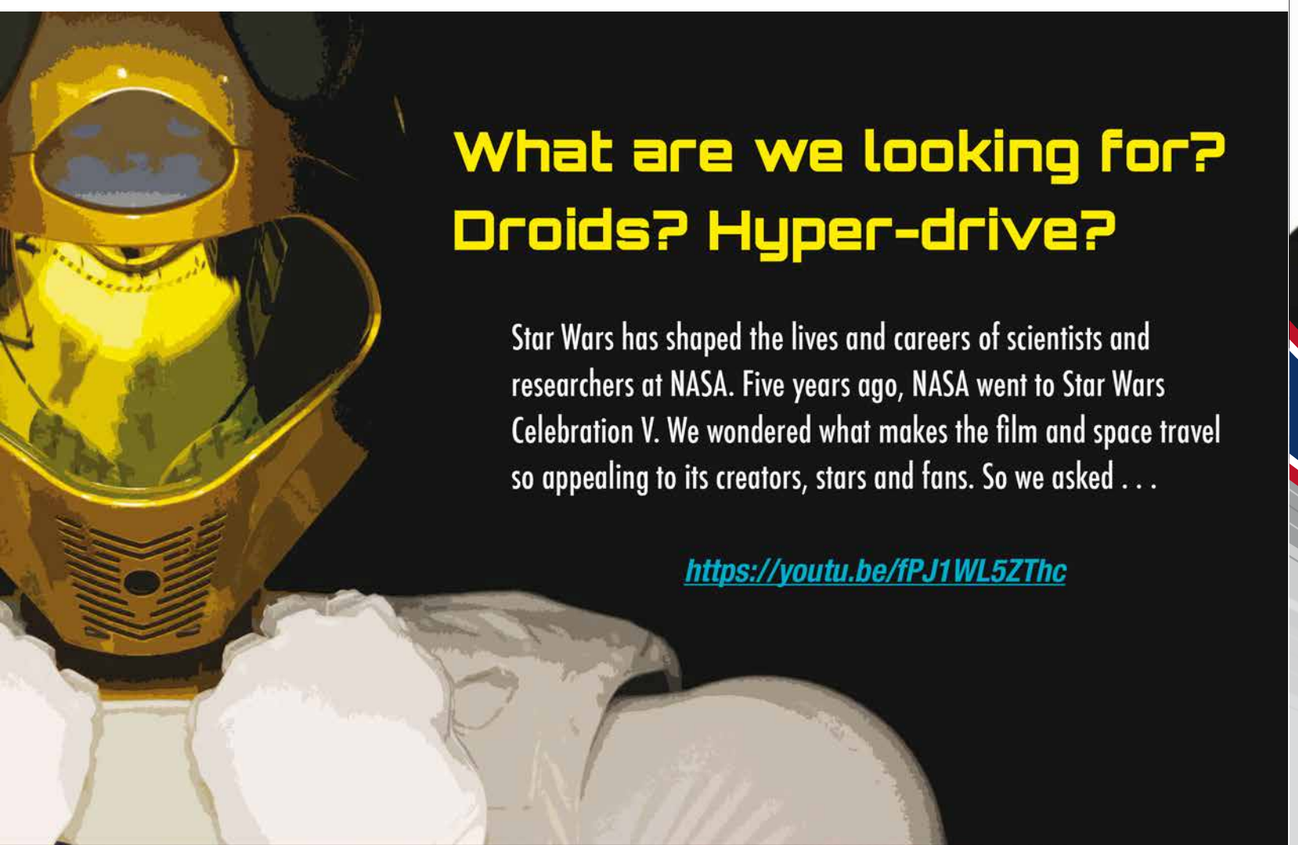
After getting permission from Granath's parents, Davis strapped the wide-eyed aviation enthusiast on a cushion in the back seat of a bi-plane. Granath didn't recall what event brought together the crowd that would be the target for the candy drop.

"At that age, it was the most exciting thing I'd had the chance to do," Granath said. "It was great just having the chance to fly."

During the next eight years, Davis repeated the process in 40 states, usually with the assistance of young aviation buffs such as Granath.

To assist in dropping Baby Ruth candy bar samples, Doug Davis enlisted 11-year-old Buster Granath. An aviation enthusiast, Granath frequently dropped by the Candler Field airport to talk to the pilots. He is pictured here in 1931 wearing a sailor suit. Granath would go on to serve in the U.S. Navy during World War II. Photo credit: Courtesy of A. E. Granath Jr. family

Pictured here in 2002, Granath built numerous model airplanes over the years including complex radio-controlled aircraft such as the one shown. Photo credit: Courtesy of A. E. Granath Jr. family



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PROJECT GEMINI

PART 4

The Gemini VII spacecraft as seen from Gemini VI during their rendezvous mission Dec. 15, 1965. At this point, the two are about 43 feet apart. Photo credit: NASA

Dual Gemini flights achieve crucial spaceflight milestones

BY BOB GRANATH

The flights of two piloted spacecraft during December 1965 were major strides forward in advancing NASA's capabilities in human spaceflight. They also marked the point in which the United States clearly pulled ahead in the space race with the Soviet Union.

While Gemini VII orbited the Earth for two weeks, Gemini VI was launched, completing the first-ever rendezvous between two spacecraft in orbit. It was a transformative capability that was not only necessary for the Apollo moon landing missions, but crucial in building and operating the International Space Station. The rendezvous marked the first time a human spaceflight milestone was achieved by the United States first.

Although the Soviet Union twice had launched simultaneous pairs of Vostok spacecraft in 1962 and 1963, the cosmonauts only established radio contact, coming no closer than several miles of each other.

The original plan for Gemini VI was to launch an unpiloted Agena upper stage atop an Atlas rocket on Oct. 25, 1965. As the target vehicle completed its first orbit, a Titan II launch vehicle was to lift off with astronauts Wally Schirra and Tom Stafford aboard. Gemini VI then would rendezvous and dock with the Agena.

After the Atlas rocket lifted off, the Agena's secondary engines fired to separate it from the launch vehicle. However, immediately after the Agena's primary engine fired, telemetry was lost and the target vehicle failed to reach orbit. The launch of Gemini VI was postponed.

Schirra was a member of the original seven astronauts having flown Mercury 8 for six orbits on Oct. 3, 1962. He would go on to command the first piloted Apollo mission in October 1968, becoming the only astronaut to fly in Mercury, Gemini and Apollo.

Stafford, one of nine pilots selected in NASA's second group of astronauts, would serve as commander for Gemini IX in 1966, and Apollo 10, the lunar landing rehearsal mission, in 1969. He also commanded the crew of the American spacecraft that linked up with two Soviet cosmonauts as part of the Apollo-Soyuz Test Project in 1975.

Gemini VII pilot Jim Lovell, in front, and command pilot Frank Borman leave the suit up trailer at Cape Kennedy's Launch Complex 16 during prelaunch countdown on Dec. 4, 1965. They are wearing lightweight pressure suits designed to be removable during their marathon 14-day mission. Photo credit: NASA

Since the next Agena target vehicle would not be ready for several months, a new plan began to take shape for Schirra and Stafford.

According to "On the Shoulders of Titans: A History of Project Gemini,"

Gemini VI's Titan first stage engines shut down 1.5 seconds after ignition on Dec. 12, 1965 due to a premature release of a liftoff umbilical plug. Wally Schirra and Tom Stafford successfully launched to a rendezvous with Gemini VII three days later. Photo credit: NASA

Walter Burke, spacecraft chief at McDonnell Aircraft Corp., and his deputy, John Yardley, asked, "Why couldn't we launch a Gemini as a target instead of an Agena?" McDonnell was the contractor that built the Gemini spacecraft.

NASA officials at the agency's headquarters in Washington D.C., Cape Kennedy (now Cape Canaveral) in Florida and the Manned Spacecraft Center (now Johnson Space Center) in Texas quickly began drawing up a plan to orbit Gemini VII on its planned two-week mission and, if there was no serious damage to Launch Pad 19, send up Gemini VI to rendezvous.

At first glance, some were skeptical.

"When I first heard of this plan to rendezvous two spacecraft by launching the second spacecraft from the same pad in nine days I thought it was next to impossible," said Andre Meyer Jr., senior assistant to the Gemini Program manager: "It normally takes nine weeks or 63 days of actual work to clean up the pad, erect the booster, mate the spacecraft and check out the systems."

Wiley Williams, NASA's manager of Gemini Operations at the Kennedy Space Center, explained that, while challenging, the quick turnaround was achievable.

"Barring unforeseen problems, we feel there is no reason why this schedule, tight as it is, cannot be met," he said at the time. "Our most critical period will be after Gemini VII is gone. We are planning for only a few days 'turnaround' time on the pad."

According to Charles Berry, M.D., chief of Medical Programs at the Manned Spacecraft Center, Gemini VII basically was an effort to better understand how humans adapt to microgravity.

"It's the culmination of our efforts to double man's exposure to the space environment with a 14-day flight," he said. "The mission will show us that man, indeed, can adapt. That his body does not show changes that increase with his exposure to that environment. The additional data will allow us to medically commit man to a lunar mission."

The Gemini VII crew, Frank Borman and Jim Lovell, were both from the second group of astronauts. While Lovell would go on to be command pilot of Gemini XII in late 1966, both would fly together again, with Bill Anders, as part of Apollo 8, the first astronauts to orbit the moon in December 1968. As commander of Apollo 13 in 1970, Lovell became the first person to fly four times.

"We're on our way, Frank," said Lovell as Gemini VII launched Dec. 4, 1965.

As the rocket exhaust began to clear, teams were standing by to begin preparing for Gemini VI.

"I was in the control center at Cape Kennedy watching the launch of Gemini VII and as the spacecraft was continuing into orbit, I glanced at another TV monitor and it showed the next launch vehicle being wheeled out of the hanger," said NASA Gemini Program Manager Charles Matthews. "That's how fast the action was taking place."

The longest previous spaceflight was the eight-day mission of Gemini V. Borman noted that he and Lovell hoped to take advantage of the earlier experiences.

"One of the things we got from Gemini V was that flying in the heavier spacesuits was very debilitating," he said. "So we were able to convince NASA that we should have a lightweight pressure suit which was developed in a very short period of time. It was very convenient because we could get out of it, and we did."

Borman and Lovell's work was set up to coincide with that of the prime shift team in Mission Control Houston, with both astronauts working and sleeping at the same time. The Gemini VII crew conducted 20 experiments, the most of any Gemini mission, including studies of nutrition in space.

The next attempt to launch Schirra and Stafford turned out to be one of the most harrowing in the history of America's still young space program.

On Dec. 12, 1965, all had proceeded well right up to ignition of the twin Titan II first stage engines. Astronaut Alan Bean was serving as capsule communicator, or capcom.

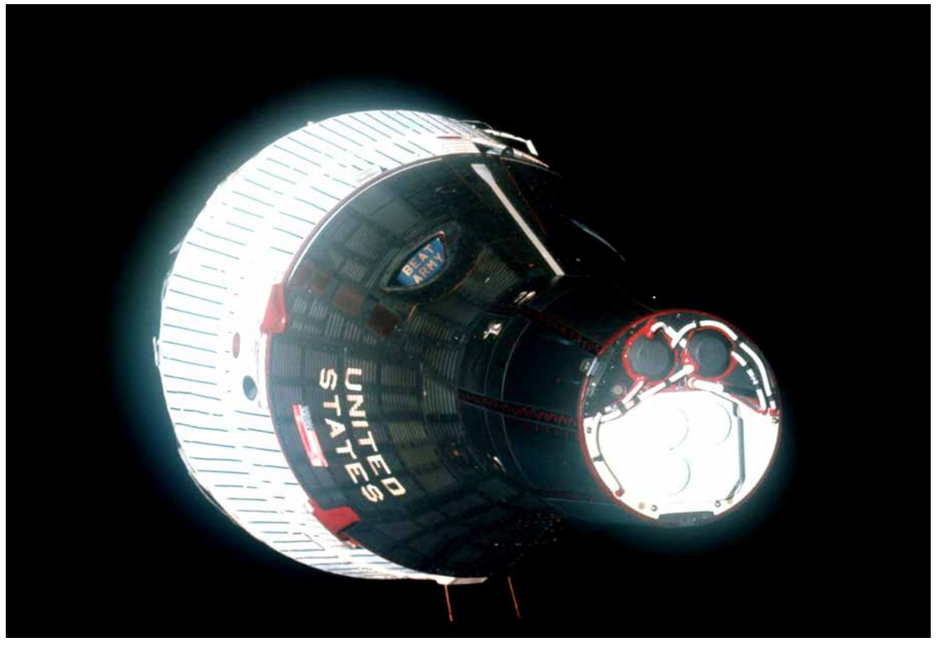
"3, 2, 1, ignition . . . shutdown Gemini VI," he said.

After about 1.5 seconds of firing, the engines abruptly shut down. There was no liftoff.

"My clock has started," Schirra said.

Since the clock had started in the spacecraft, the instruments were telling Schirra liftoff had taken place. Mission rules dictated that he should immediately pull a D-shaped ring above the center console and activate the ejection seats, blasting the astronauts safely away from the fully fueled Titan II which would be falling back to the launch pad. However, Schirra's experience from Mercury 8 paid off. He did not feel the motion of liftoff.

"I knew we hadn't gone anywhere," he said later. "This proves that man is better programed than any computer."



This view of the Gemini VI spacecraft includes a "Beat Army" sign in the window. The message from the on-board crew of Wally Schirra and Tom Stafford, who, along with Gemini VII pilot Jim Lovell, are all graduates of the U.S. Naval Academy. Gemini VII command pilot, Frank Borman, is an alumnus of the U.S. Military Academy. That year's matchup between the two service academies was played on Nov. 27, 1965, ending in a 7-7 tie. Photo credit: NASA

"One of the things we got from Gemini V was that flying in the heavier spacesuits was very debilitating. So we were able to convince NASA that we should have a lightweight pressure suit which was developed in a very short period of time. It was very convenient because we could get out of it, and we did."

Frank Borman
Former Astronaut

An evaluation determined that a tail plug fell off prematurely causing the engine shutdown and the erroneous liftoff signal.

Three days later, Schirra and Stafford were finally on their way to catch up with Borman and Lovell.

The radar on Gemini VI first made contact with Gemini VII after 3 hours and 15 minutes when they were 270 miles away. Soon thereafter, Schirra established voice contact with Borman.

"We're looking for you," the Gemini VI command pilot said. "Hang on, we'll be up there shortly."

About six hours after liftoff, while passing over the Hawaii tracking station on Gemini VI's fourth orbit, Schirra reported that he and Stafford had caught up with Borman and Lovell.

"We're flying in formation with (Gemini) VII," Schirra said. "Everything is go here."

"Roger, congratulations, excellent," said astronaut Elliott See, the capcom.

"Thank you, it was a lot of fun," said Schirra.

During the next five and a half hours of station keeping, the crews moved as close as one foot, taking pictures and describing the appearance of each spacecraft.

"Looks like the flag and the letters are seared as much at launch as they are when you come back at re-entry," Lovell said, describing the side of Gemini VI.

Later, Gemini VI fired its thrusters and slowly drifted out to 10 miles, preventing an accidental collision during their sleep period.

Before the end of the day, and noting the upcoming holiday, the Gemini VI crew had a surprise for everyone.

"Gemini VII, this is Gemini VI," Schirra said. "We have an object, looks like a satellite going from north to south, probably in a polar orbit. He's in a very low trajectory. Looks like he might be going to re-enter soon. Stand by one ..."

At that point, the sound of "Jingle Bells" was heard being played by Schirra on a small harmonica with Stafford ringing a handful of small bells.

"You're too much, VI," laughed See from mission control.

Gemini VI re-entered the next day, landing in the Atlantic Ocean within 10 miles of the aircraft carrier, USS Wasp.

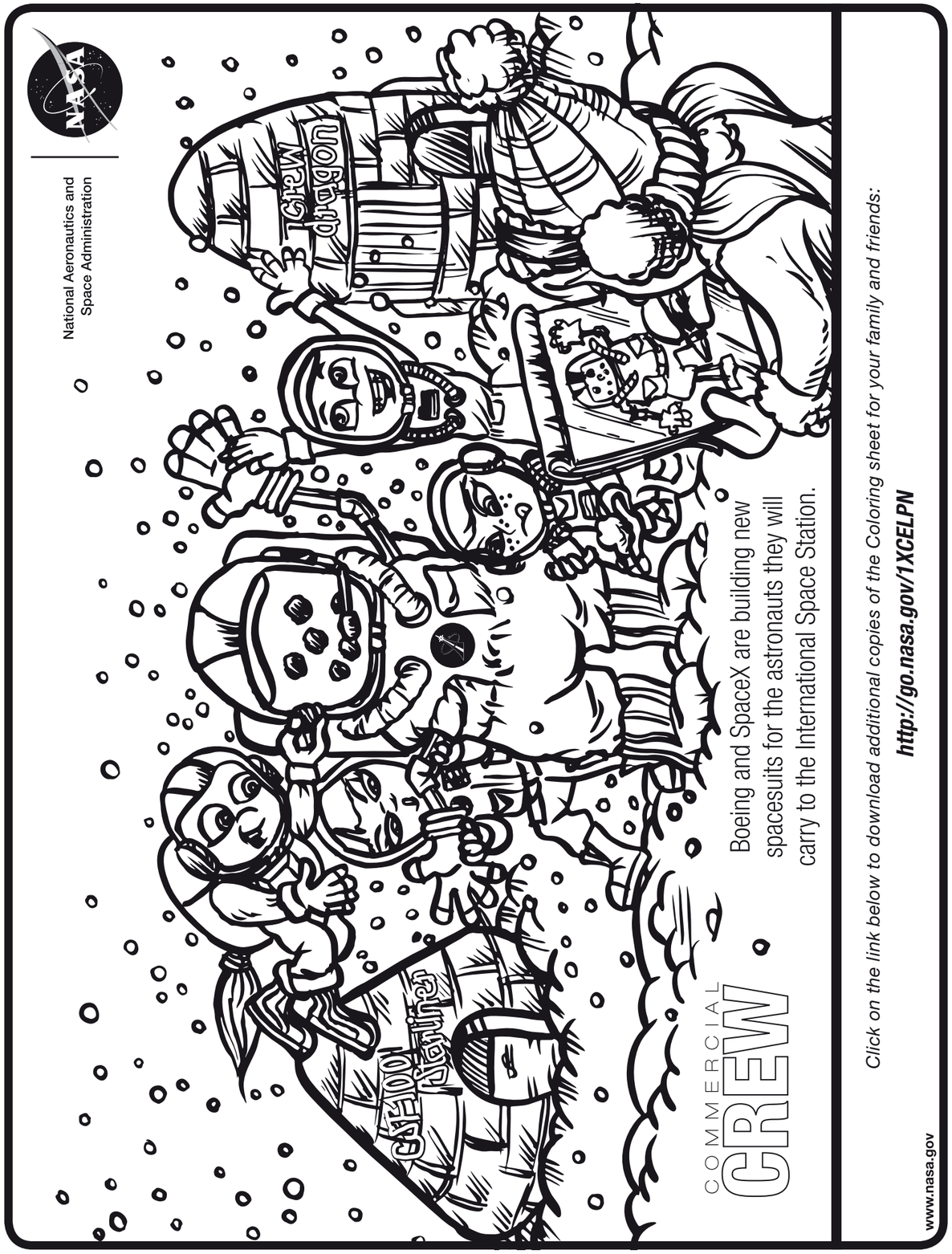
The recovery of Schirra and Stafford also was the first to be televised. Through a transportable satellite Earth station on the deck of the Wasp, television networks were able to provide live coverage.

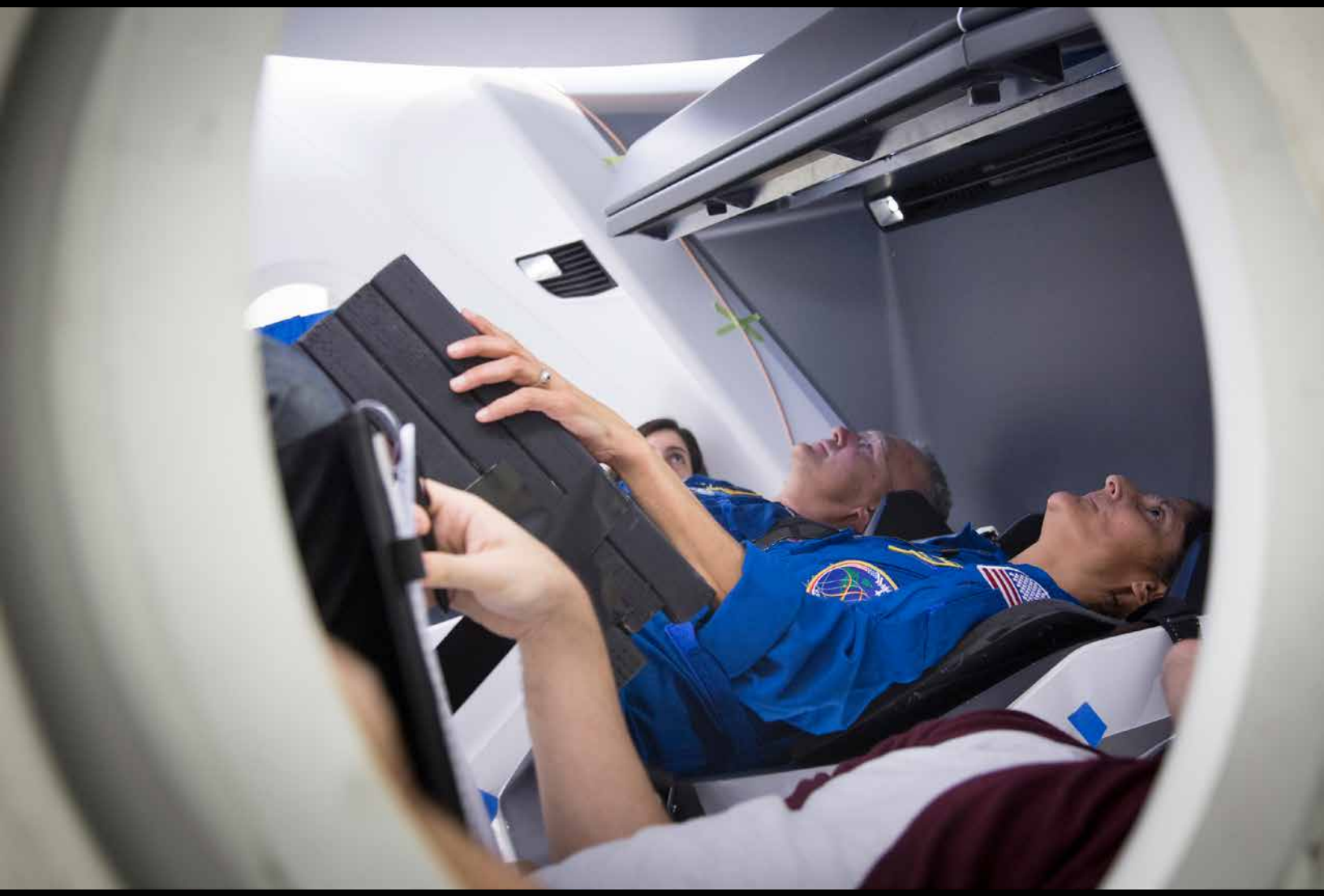
Gemini VII remained in space two days after Gemini VI's return, landing Dec. 18, 1965. Borman and Lovell held the world record for the longest human spaceflight until the 17-day Soyuz 9 mission in June 1970 and were U.S. record holders until the Skylab missions in 1973 and 1974.

"The VII and VI missions were a very fitting climax to a successful year of Gemini flights," said Matthews. "Gemini IV introduced us to spacewalking and was also the start of our buildup of long duration missions and went four days. Gemini V, in turn, went eight days. This effort on the (Gemini) 7/6 mission, is an example of the American spirit as it has existed throughout the years and is ample evidence that it exists today."

Surrounded by NASA dignitaries and members of the crew of the aircraft carrier USS Wasp, Gemini VII astronauts Frank Borman and Jim Lovell arrive aboard the ship following their recovery Dec. 18, 1965. The astronauts were picked up from the Atlantic Ocean, following successful splashdown after two weeks in orbit. Photo credit: NASA

EDITOR'S NOTE: This is the fourth in a series of feature articles marking the 50th anniversary of Project Gemini. The program was designed as a steppingstone toward landing on the moon. The investment also provided technology now used in NASA's work aboard the International Space Station and planning for the Journey to Mars. In March, read about the first docking mission and responding to an emergency in space. For more see "On the Shoulders of Titans: A History of Project Gemini."





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. Photo credit: SpaceX

For more on the astronauts' evaluation of the Crew Dragon, go to http://go.nasa.gov/1XqCT1Q

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