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KENNEDY SPACE CENTER'S

SPACEPORT magazine

DUST TO THRUST

LIVING OFF THE LAND, OFF THE EARTH

KENNEDY SPACE CENTER'S

SPACEPORT MAGAZINE

CONTENTS

Cover: An integrated test of the MARCO POLO/Mars Pathfinder in-situ resource utilization, or ISRU, system recently took place at NASA's Kennedy Space Center in Florida. A mockup of MARCO POLO, an ISRU propellant production technology demonstration simulated mission, was tested in a regolith bin with RASSOR 2.0, the Regolith Advanced Surface Systems Operations Robot. RASSOR excavated regolith and delivered sand and gravel to a hopper and mock oven. On the surface of Mars, mining robots like RASSOR will dig down into the regolith and take the material to a processing plant where usable elements such as hydrogen, oxygen and water can be extracted for life support systems. Regolith also shows promise for both construction and creating elements for rocket fuel for the Mars Ascent Vehicle which will bring the astronauts home from Mars. Photo credit: NASA/Dimitri Gerondidakis

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KSC BLOG

THE SPACEPORT MAGAZINE TEAM

Editorial

Editor.....Frank Ochoa-Gonzales

Assistant Editor.....Linda Herridge

Copy Editor.....Kay Grinter

Writers Group

Anna Heiney, Bob Granath, Kay Grinter, Linda Herridge, Steven Siceloff

Creative Group

Richard Beard, Amy Lombardo, Lynda Brammer, Matthew Young, Greg Lee

NASA'S LAUNCH SCHEDULE

Targeted Date: Oct. 9
Mission: Orbital ATK Resupply Mission to Space Station (Orbital CRS-5)
Description: Orbital ATK's Cygnus cargo delivery to the International Space Station is targeted for a mid September launch on the Antares rocket from the Mid-Atlantic Regional Spaceport's Pad OA at NASA Wallops Flight Facility in Virginia.

Date: Oct. 20
Mission: Progress 65 Launch
Description: The Russian Progress 65 cargo craft will launch to the International Space Station from the Baikonur Cosmodrome in Kazakhstan on a two-day trip to the International Space Station, delivering food, fuel and supplies.
http://go.nasa.gov/2dy7lHk

Date: Nov. 4, 5:40 p.m. EDT
Mission: Geostationary Operational Environmental Satellite-R Series (GOES-R)
Description: The advanced spacecraft and instrument technology used on the GOES-R series will result in more timely and accurate forecasts and warnings.
http://go.nasa.gov/1YubP2g

Date: Nov. 15, 4:05 p.m. EDT
Mission: Expedition 50 Launch
Description: NASA astronaut Peggy Whitson, cosmonaut Oleg Novitskiy of the Russian space agency Roscosmos and European Space Agency astronaut Thomas Pesquet will launch to the space station aboard the Soyuz MS-02 spacecraft from the Baikonur Cosmodrome in Kazakhstan.
http://go.nasa.gov/1VHuSAv

Date: Nov. 21
Mission: Cyclone Global Navigation Satellite System (CYGNSS)
Description: Launching from Cape Canaveral Air Force Station, Florida, on a Pegasus XL rocket, the CYGNSS mission will probe the inner core of hurricanes to learn about their rapid intensification.
http://www.nasa.gov/cygnss

I am KENNEDY SPACE CENTER

TONY GANNON

I have had the honor of working with Space Florida since the organization's inception, and currently serve as the director of business development. It's a challenging position, and I am responsible for initiating business development opportunities and partnerships that capture expansion activities and increase Florida's aerospace industry market share. That's a tall order for a man who was raised in Ireland and who fell in love with the space program at an early age. I count myself amongst the very lucky ones.

In the past, I initiated Space Florida Academy and Internship Programs, the Sub-Orbital Flight Incentive Program and the Space Florida — International Space Station (ISS) Research Competition. That was a most exciting project, resulting in seven scientific payloads flying to the space station.

As director of business development, I work to gather economic data, specifically as it relates to Florida's growing aerospace industry. I also spearhead Space Florida's Capital Acceleration Programs in efforts to raise venture capital within the state of Florida. To date, more than $84 million has been raised for participating Florida companies with the assistance of our partnering entity — the Florida Venture Forum.

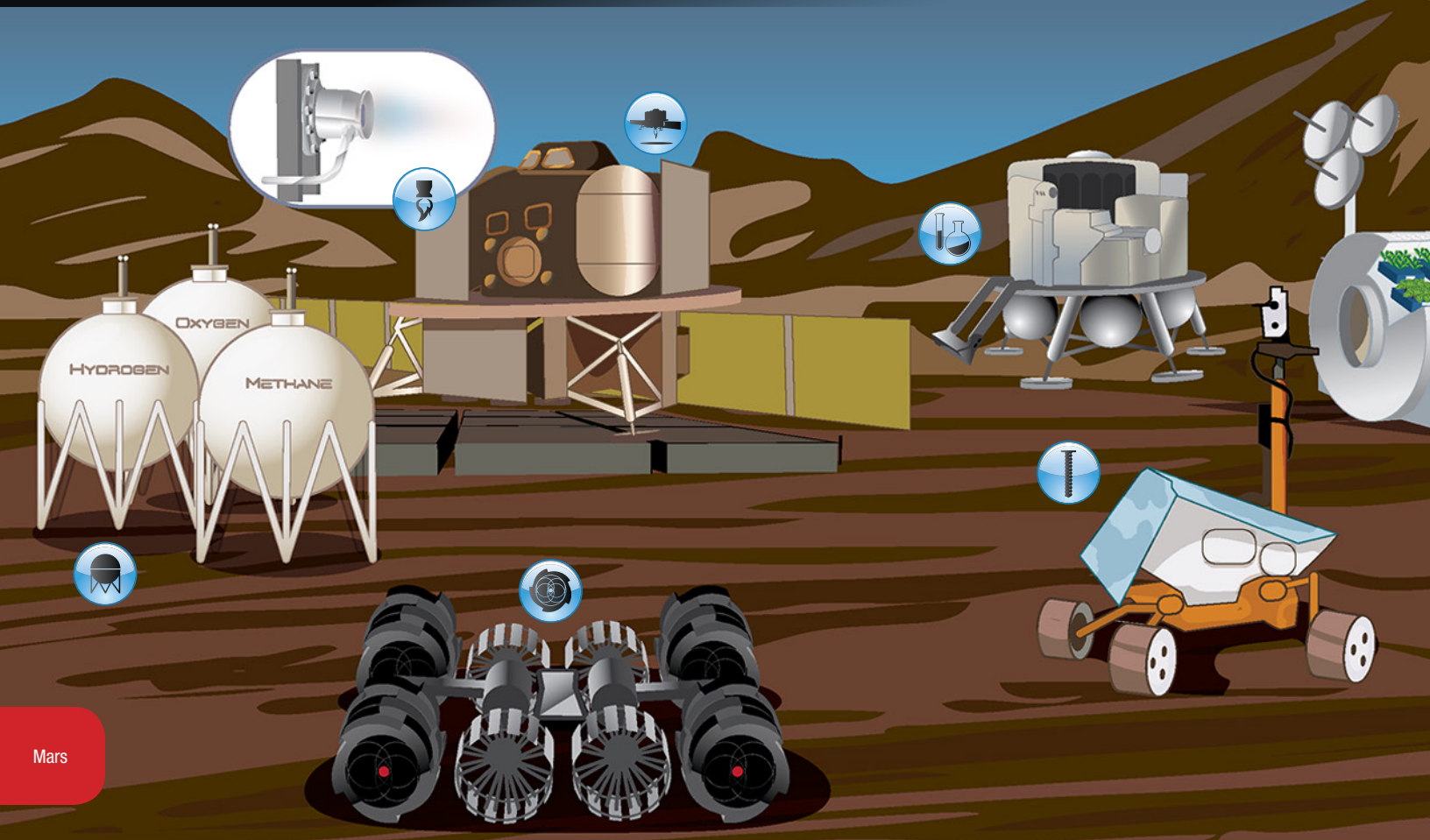
I also lead Space Florida's activities in the Florida-Israel Innovation Partnership, an international program with Israel that supports joint research and development, as well as commercialization efforts of aerospace and related technical projects.

Working here at Kennedy has been the highlight of my career. It has afforded me great opportunities and tough challenges, all of which I have welcomed. Who could want more than that?

Dust to Thrust

SWAMP WORKS
NASA KENNEDY SPACE CENTER

Exploration Research and Technology Programs



Mars

Prospector

Miner

Processor

Cryogenic Storage

Pioneering space requires living off the land in the solar system

BY BOB GRANATH

As NASA continues preparing for the Journey to Mars, the technology now in development is expanding beyond the spacecraft and propulsion systems needed to get there. NASA scientists and engineers also are developing systems to harness abundant resources available in the solar system to support these pioneering missions.

The practice is called in-situ resource utilization, or ISRU. Like early European settlers coming to America, planetary pioneers will not be able to take everything they need, so many supplies will need to be gathered and made on site.

The concept focuses on how to turn a planetary body's atmosphere and dusty soils into everything from building materials for shelters on Mars to rocket fuel for the trip back to Earth.

Much of this work is taking place at Kenney Space Center. Center Director Bob Cabana recently explained that the agency is moving to a new era in space travel.

"It was an incredible accomplishment when we went to the moon," said Cabana, a former space shuttle astronaut. "We stayed for a couple of days and took some rocks home. We explored."

Cabana noted that explorers leave a nice, safe environment. They go off to an extreme environment for a short period of time, gather information and return.

"But, now we want to be pioneers," he said. "As pioneers, we will create a sustained human presence in an ever more extreme environment."

In the agency's first half-century, the focus was on quick trips to space for hours, then days followed by weeks, primarily close to Earth and the moon, just a few travel days away.

Since November of 2000, NASA and its global partners have participated in the next phase by establishing a permanent presence in low-Earth orbit aboard the International Space Station where astronauts are learning to live and work in space for longer periods of time.

"We now want to go to Mars," Cabana said.

Images depicted are conceptual designs

Human Habitat

Plant Habitat

Methane Engine Fuel

Mars Ascent Vehicle

Annie Meier adjusts the trash-to-gas reactor that she is helping develop to recycle trash during deep-space missions. Unneeded materials such as scraps, wrappers, packaging and other garbage could be converted into methane gas, oxygen and water.
Photo credit: NASA/Dan Casper

In-situ Resource Utilization

A mission to the Red Planet would be about six to nine months each way, plus the time spent on the surface. That would be without the benefit of frequent resupply missions, making it all the more important to use available resources. Dr. Jim Mantovani, a Kennedy planetary scientist and granular physics researcher, spoke of the challenges of developing ways to use ISRU as a stepping stone to Mars.

"The goal of ISRU includes making consumables for life support and propellant for rockets," he said.

Mantovani pointed out that the equipment must be able to operate in the punishing surroundings of distant worlds. Near the poles of Mars, temperatures can plummet to minus 195 degrees Fahrenheit. However, near the Red Planet's equator, a summer day could be a pleasant 70 degrees. The atmosphere on Mars is about 95 percent carbon dioxide.

"To (use ISRU resources) on a remote planet or an asteroid, the systems need to be very reliable," he said.

Rob Mueller, a senior technologist in the Spaceport Systems Branch of Exploration Research and Technology Programs at Kennedy, believes that in spite of the extreme environment, the atmosphere and soil will prove useful. But a crucial decision will involve landing humans where robotic probes have found the needed resources.

"We don't want to land somewhere and assume there is water in the regolith and find there is no water," he said. "We need to prospect before we mine to see if there is anything valuable there. So, in order to do the prospecting, NASA is planning an orbital mission with instruments on board to look for water in the soil using remote sensing."

That orbiter may be similar to the Mars Reconnaissance Orbiter circling the Red Planet searching for evidence that water exists on the surface.

When areas prove promising, Mueller says the next step is using rovers on the surface to confirm the presence of needed resources.

Prospecting for Resources

In the meantime, NASA's Resource Prospector mission aims to be the first mining expedition on another world, building on the findings of NASA's Lunar Crater Observation and Sensing Satellite (LCROSS) and Lunar Reconnaissance Orbiter (LRO) missions.

"Our objective is to go to the moon's poles where the LCROSS and LRO missions told us that what we previously thought was a dry moon is actually a quite moist moon," said Jackie Quinn, Kennedy's project manager for Resource Prospector.

The Resource Prospector mission could potentially launch toward the moon early in the 2020s. The robot will use instruments to locate elements at a lunar polar region and excavate and sample resources such as hydrogen, oxygen and water that could support human explores orbiting above the moon or on their way to destinations such as Mars and farther into the solar system.

The technologies and operations capabilities that Resource Prospector validates also could help determine how to someday harvest resources on Mars, an asteroid or other planetary bodies.

Once resources are confirmed, astronauts will need tools to harvest enough regolith to construct shelters and manufacture

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

rocket fuel, as well as extract water from ice on the Martian surface.

Regolith is the layer of loose or dusty unconsolidated rocky material covering bedrock.

Mining on Mars

According to Mueller, NASA had to find a new way to dig on low-gravity planets. Gravity on Mars is 62 percent lower than that of Earth. As a result, excavators do not need to be as big as their counterparts on Earth.

Mining for resources may be performed by a robot called RASSOR, for Regolith Advanced Surface Systems Operations Robot.

Aboard the International Space Station on Aug. 10, 2015, NASA astronauts Kjell Lindgren, left, and Scott Kelly shared the first taste of food that was grown, harvested and eaten in space, a critical step on the path to Mars. Photo credit: NASA

"It can't take one big scoop but takes lots of small scoops," Mueller said.

He noted that the basic technology is not new, just the application.

"Our ancestors found that lots of small scoops on a wheel is quite efficient," Mueller said. "It's called a bucket wheel. So we turned a bucket wheel into a bucket drum. Then you can dig quite efficiently with lots of small scoops."

Once the miner has collected regolith, it is then processed to create water, hydrogen and oxygen. The regolith also could be put to use in three-dimensional printing of shelters and other structures. This printing process refers to processes used to create an object of almost any shape or geometry in which successive layers of material are formed under computer control.

Crops in Space

Another need of deep-space traveling astronauts is food. Dr. Gioia Massa, a Kennedy project scientist in the space center's Exploration Research and Technology Programs Directorate, researches food production in space.

"Food is something we all depend on, and it's not going to be easy to get food out of regolith," she said. "Right now, we pretty much take all our food along to the space station. But seeds are very small. Seeds are easy to take."

Massa has helped lead successful efforts studying plant growth aboard the space station.

"There are a number of different types of plants we can grow," she said. "We can start with produce that is just fresh that you can pick and eat. Other crops, such as potatoes, can be added depending on available time and resources."

NASA researchers on Earth and aboard the station are working to find optimum growing environments for plants and crops including lighting, nutrients and watering, all while dealing with microgravity.

Plant growth research also includes finding ways to produce food autonomously, freeing up crews to focus on their mission.

"This is another opportunity for robotics, when you have astronauts who are busy doing a lot of other activities," Massa said. "Having robots to take care of the plants could be very helpful."

Trash to Gas

As a Kennedy chemical engineer, Annie Meier is part of a team developing a technology that could turn ordinary debris and other garbage accumulated by a crew of astronauts into valuable resources.

"There is food waste, there is biological waste, there is packaging waste," she said. "Here at Kennedy, we're working on how to make this waste into useful products, such as methane for fuel."

The trash reactor being tested at Kennedy can hold more than three quarts of material and burns at about 1,000 degrees Fahrenheit, about twice the maximum temperature of an average household oven. The end result is useful elements.

Experiments have shown that 10 pounds of trash could be converted into seven pounds of rocket fuel. Other valuable byproducts of the trash reactor include oxygen and water.

"It costs a great deal to launch a ton of payload beyond Earth orbit," Meier said, "so why not reuse it."

The resulting savings are significant. Making about two pounds of fuel on Mars saves about 500 pounds launching it from Earth to get it to the Red Planet.

The greatest challenge for missions of a year or more is becoming Earth independent. Projects that focus on resource utilization are part of ongoing efforts to do just that, moving from space exploration to pioneering.

"We don't just want to go explore," Cabana said, "we want to pioneer; we want to establish a presence in the solar system."

Watch a RASSOR demonstration at: http://go.nasa.gov/2dBpLXB

Future of Food

Farming in 'Martian Gardens'

BY ANNA HEINEY

Of the many challenges involved in sending humans on the journey to Mars, figuring out how to pack enough food for such a lengthy trip looms large. Of course, astronauts will need food on their way to and from Mars, and also during their time on the Red Planet as part of the almost two-and-a-half-year trip. Although prepackaged food will be provided, stowing space-saving seeds to grow one's own food provides extra nutrition and even increases morale by sprouting a glimpse of home while millions of miles away from Earth.

Kennedy Space Center is partnering with the Florida Tech Buzz Aldrin Space Institute in Melbourne, Florida, to collaborate on research studying the performance of crop species grown in a simulated "Martian garden" — a proving ground for a potential future farm on the Red Planet.

"We are using advances in science to learn about increasing plant production to supplement astronauts' diets," said Trent Smith, Veggie Project Manager at NASA's Kennedy Space Center in Florida. Veggie is a plant-growth unit enabling space gardening and space plant biology experiments on the International Space Station.

"Soil, by definition, contains organics; it has held plant life, insects, worms. Mars doesn't really have soil," said Ralph Fritsche, the senior project manager for food production at Kennedy Space Center.

Instead, the Red Planet is covered with regolith: crushed volcanic rock containing nothing organic. But it does contain some toxic chemicals, adding to the complexity of the challenge at hand.

The 100 pounds of Martian soil simulant being used at Florida Tech comes from Hawaii and was chosen based on spectral data from Mars orbiters. It will be a common simulant used for testing the performance of the hardware systems used to grow plants. The Florida Tech team will experiment with which and how much nutrients should be added to the simulant for optimal plant growth of various crops

During a 3.5-week pilot study, Drew Palmer, a professor of biochemistry and chemical ecology at Florida Tech, and Brooke Wheeler, an ecologist and professor in the College of Aeronautics at Florida Tech, grew lettuce plant[illegible] s: one in simulant, one in simulant with added utrients, and one in potting soil. The study began with 30 seeds [illegible] in the simulant, and ended with only half as many; although they tasted the same as the others, their roots were not as strong as the potting soil plants.

This preliminary research also found that germination rates were two to three days slower than in control groups, and therefore it's important to gain an understanding of how the timelines involved in Martian farming differ from growth times on Earth.

Plants were grown in a preliminary experiment comparing (left to right) potting soil, regolith simulant with added nutrients, and simulant without nutrients. Photo credit: NASA/Dimitri Gerondidakis

NASA plans to grow food on future spacecraft and on other planets as a food supplement for astronauts. Fresh food, such as vegetables, provide essential vitamins and nutrients that will help enable sustainable deep space pioneering. Credits: NASA

"Soil, by definition, contains organics; it has held plant life, insects, worms. Mars doesn't really have soil."

– Ralph Fritsche
Senior Project Manager for Food Production at Kennedy Space Center

According to Fritsche, this study will document and publish scientific data on growing plants in a widely available Martian simulant, providing a control for future studies.

Some of the plants they may try to grow during the nine-month test include radishes, Swiss chard, kale, Chinese cabbage, snow peas, dwarf peppers and tomatoes — all nutritious foods and, more importantly, all tested and selected menu items for astronauts.

NASA and Florida Tech formally signed the agreement in June 2016 and testing officially began in mid-September. A preliminary report on the test results is expected in mid-January 2017, with the final report planned for March 2017.

The teams are working together to define the test strategies and the data to be gathered, and will collaborate again to analyze the data and test results. NASA scientists are providing expertise on the selection of Martian simulant being used, as well as the initial setup and start of the test. They'll also help assess the health of the growing plants in concert with the Florida Tech faculty. Florida Tech is providing the plant seeds, Martian regolith simulant, growth volume, equipment, and most importantly plant care and data collection by students and professors. The Florida Tech team also will write the post-test report.

Discoveries made in these Earth-based "Martian gardens" will pave the way for future studies and technology development in terms of reliable, efficient food production a long way from the home planet, Fritsche said.

"We're right at the cutting edge of this research."

I Will LAUNCH AMERICA

Restoring America's Human Launch Capability

Kathleen "K.O." O'Brady
Certification System Engineer Lead
NASA's Commercial Crew Program

I Will Launch America: Kathleen O'Brady

BY STEVEN SICELOFF

Kathleen O'Brady can't say she's put in more time at NASA's Commercial Crew Program than anyone else, but she can say she's had days when she felt like she never went home. She also knows that as the commercial crew team pushes toward launching human-rated spacecraft on flight tests beginning in 2017, many people in NASA and at Boeing and SpaceX are going to feel the same way.

"Every day it becomes more and more real, because you're watching the hardware come together and you're thinking, 'someone is going to ride on these,'" O'Brady said.

Fortunately, the intensity, commitment and enthusiasm from those working in the program is abundant, O'Brady said.

"I would say all of commercial crew is type A-plus," she said. "Commercial crew isn't the biggest program we have at NASA; however, I can say with certainty that everyone at the program gives it their all. We all know the importance of launching our astronauts from American soil and are excited to work with the providers to meet that need."

O'Brady grew up in Connecticut and checked out library books as a child to find out about space. She was hooked.

"I was definitely the kid who wanted to be an astronaut at five years old," O'Brady said. "I'd still love the chance to fly with either of our partners."

O'Brady put herself on course for an engineering degree, figuring she would be ready for whatever professions opened up at NASA. She came to NASA's Kennedy Space Center in Florida in 2004 to work on the fuel cells that powered space shuttles as they orbited Earth.

"I'm just honored that I got the opportunity to work on shuttle," O'Brady said. "The weirdest feeling is when you meet new, young employees and interns and you realize they didn't work on it. Then I feel old, and I'm only 32. That experience was special and I'm humbled every time. It definitely helped me mature into the role I have now."

O'Brady began her time with commercial crew working on contract source evaluation boards — the committees of specialized engineers, government officers and lawyers that develop contract requirements, analyze proposals and present the findings to the person who makes the final decision. The boards are small groups that work in secluded rooms by themselves for months at a time, often arriving before the sun rises and leaving long after it's gone down.

"On a source board, you are one of 10 or 15 people and your job is reviewing roughly thousands of pages in three months," O'Brady said. "The folks you work with become your family, because you're with them for all those hours, six and seven days a week. I wouldn't give that time back for anything."

The work performed by the source boards has been vital to NASA in achieving the goals of commercial crew, which is ultimately to turn over human missions to low-Earth orbit to private companies so NASA can focus its research and development resources on its journey to Mars, including human deep space exploration. NASA's partnerships with private aerospace industry, were established through the Space Act Agreements and contracts that stem from panels or source boards.

The final board O'Brady worked on ultimately led to the award of contracts to Boeing and SpaceX to build the spacecraft and launch systems that will return human launch capability to American soil. Each company works independently on different systems – Boeing is building the CST-100 Starliner to launch on a United Launch Alliance Atlas V rocket and SpaceX is building the Crew Dragon to launch on a Falcon 9 rocket. Both work closely with NASA to build systems that meet NASA's safety and performance requirements. One goal of this unique approach is to acquire cost-effective transportation services from providers that own and maintain the spacecraft systems themselves. The companies also expect to offer orbital flights for non-NASA customers in the future.

"It's definitely different than a traditional program where we own the hardware," O'Brady said, noting that for the space shuttle, Apollo and its predecessors the space agency owned the hardware, designs, and more of the processes used in building and maintaining the vehicles.

For the Commercial Crew Program, NASA developed approximately 300 requirements for safety and mission success in addition to the existing requirements for visiting vehicles to the International Space Station, a far smaller amount than the thousands of requirements levied during the Space Shuttle Program.

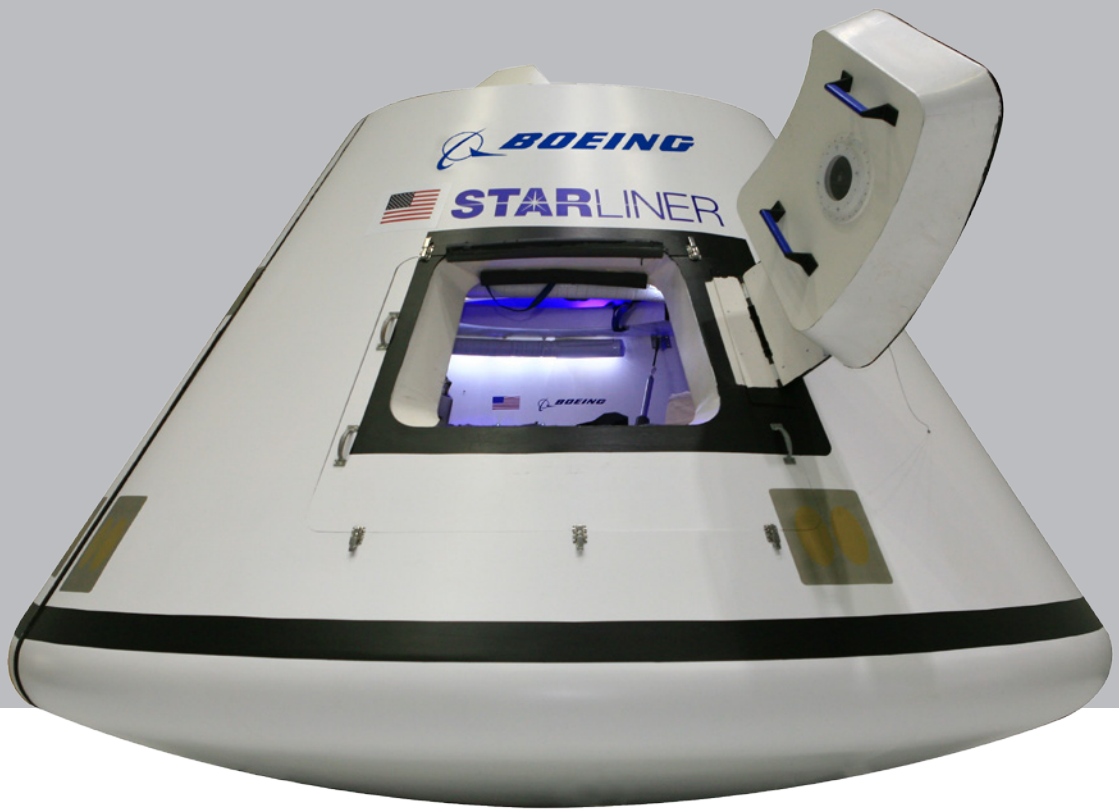
Holding degrees in aerospace engineering and physics, O'Brady's work on three of the boards was to provide engineering expertise focusing specifically on what technical requirements to ask of industry and NASA's efforts necessary to ensure those requirements were met. The board had to be confident that astronauts flying these new spacecraft would be as safe as possible traveling from Earth to the International Space Station and back.

A big part of O'Brady's tasks now revolve around confirming the companies are building crew transportation systems that work as designed.

"We all have to do the job right," O'Brady said. "We have a duty to return our astronauts to flight. We're going to use these private companies and they're going to do a fantastic job."

EVERY DAY CLOSER TO A NEW WAY TO ORBIT

ISS



STARLINER

Two years after selecting the next generation of American spacecraft and rockets that will carry astronauts to and from the International Space Station, engineers and spaceflight specialists across NASA's Commercial Crew Program, Boeing and SpaceX are putting in place the elements required for successful missions.

DRAGON

COMMERCIAL CREW

Commercial Crew astronauts, left to right, Bob Behnken, Suni Williams, Eric Boe, and Doug Hurley stand on the Crew Access Arm leading to the White Room at a construction yard near NASA's Kennedy Space Center in Florida.

HERE ARE EIGHT THINGS TO KNOW ABOUT COMMERCIAL CREW:

1. The Goal — The goal of NASA's Commercial Crew Program is to return human spaceflight launches to U.S. soil, providing reliable and cost-effective access to low-Earth orbit on systems that meet our safety requirements. To accomplish this goal, we are taking a unique approach by asking private companies, Boeing and SpaceX, to develop human spaceflight systems to take over the task of flying astronauts to station.

2. Multi-User Spaceport — Boeing and SpaceX, like other commercial aerospace companies, are capitalizing on the unique experience and infrastructure along the Space Coast at our Kennedy Space Center and Cape Canaveral Air Force Station. Kennedy has transitioned from a government-only launch complex to a premier multi-user spaceport. In the coming years, the number of launch providers along the Space Coast is expected to more than double.

3. Innovation — Our expertise has been joined with industry innovations to produce the most advanced spacecraft to ever carry humans into orbit. Each company is developing its own unique systems to meet our safety requirements, and once certified by us, the providers will begin taking astronauts to the space station.

4. Research — With two new spacecraft that can carry up to four astronauts to the International Space Station with each of our missions, the number of resident crew will increase and will double the amount of time dedicated to research. That means new technologies and advances to improve life here on Earth and a better understanding of what it will take for long duration, deep space missions, including to Mars.

5. Crew Training — Astronauts Bob Behnken, Eric Boe, Doug Hurley and Suni Williams have been selected to train to fly flight tests aboard the Boeing CST-100 Starliner and SpaceX Crew Dragon.

The veteran crew have sent time in both spacecraft evaluating and training on their systems. Both providers are responsible for developing every aspect of the mission, from the spacesuits and training, to the rocket and spacecraft.

6. Launch Abort System — Boeing and SpaceX will equip their spacecraft with launch abort systems to get astronauts out of danger . . . FAST!

7. Expedited Delivery — Time-sensitive, critical experiments performed in orbit will be returned to Earth aboard commercial crew spacecraft, and returned to the scientists on Earth in hours, instead of days — before vital results are lost. That means better life and physical science research results, like VEGGIE, heart cells, and protein crystals.

8. Lifeboat — The spacecraft will offer safe and versatile lifeboats for the crew of the space station, whether an emergency on-orbit causes the crew to shelter for a brief time in safety, or leave the orbiting laboratory altogether.
Learn more: http://go.nasa.gov/2dBggaY

WATCH HOW SPACEFLIGHT SPECIALISTS ACROSS NASA'S COMMERCIAL CREW PROGRAM, BOEING AND SPACEX ARE PUTTING IN PLACE THE ELEMENTS REQUIRED FOR SUCCESSFUL MISSIONS AT
http://go.nasa.gov/2dBfQkM

National Aeronautics and
Space Administration

FACES OF GSDO

GROUND SYSTEMS DEVELOPMENT & OPERATIONS

Liliana Villarreal
Manager, Spacecraft and Offline Operations
Ground Systems Development & Operations Program

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www.nasa.gov
SP-2016-08-244-KSC

Liliana Villarreal

Spacecraft and Offline Operations Manager

My name is Liliana Villarreal. I am the Spacecraft and Offline Operations manager for the Ground Systems Development and Operations Program at Kennedy Space Center.

I lead the team that will be responsible for the Orion and payload offline operations prior to integration with the Space Launch System rocket. This includes offline final assembly, testing and servicing of the Orion spacecraft and payloads as required. We also are responsible for the maintenance of the ground support equipment and the facilities that will be needed to complete these operations.

I began working at Kennedy in 2000 for The Boeing Company. I was a mechanical/handling and access engineer supporting assembly missions for the International Space Station (ISS). In 2007, I moved to the NASA Operations team under the ISS Program. During the Kennedy reorganization in 2014, I moved to GSDO as an integration operations manager, and then moved into my current role about a year ago.

The coolest part of my job is being part of history in the making. Eventually when we get to Mars, we will look back and know this is where it all started and that we were part of it.

The achievement I'm most proud of is the creation of the Spacecraft and Offline Operations team, which we call SOO. Everyone on this team is just amazing, and I'm very proud to be a part of this group.

I wanted to be a part of the GSDO team. I had worked for the ISS Program in one capacity or another since arriving at Kennedy, and although I'm a big fan of the space station and very proud of everything we accomplished, I felt it was time to get experience working on another NASA program.

I first became interested in space when I was seven years old. My family visited the Kennedy Space Center Visitor Complex, and from that moment on, all I wanted to be was an astronaut.

I was born in Cartagena, Colombia, and moved with my family to Miami, when I was 10. I earned a Bachelor of Arts and a master's degree in aerospace engineering from Georgia Tech. I also have a master's in management of technology from the University of Miami.

The advice I would give to students interested in a career field similar to mine is to have a goal. Lay out a plan to achieve that goal and work hard.

Also, in the words of Steve Jobs: "Your work is going to fill a large part of your life, and the only way to be truly satisfied is to do what you believe is great work. The only way to do great work is to love what you do."

The shipping container carrying the Orion heat shield for Exploration Mission 1 (EM-1) is offloaded from NASA's Super Guppy aircraft. Photo credit: NASA/ Dimitri Gerondidakis

Orion heat shield for next test flight arrives

BY LINDA HERRIDGE

The Orion heat shield, which will protect the Orion crew module during re-entry after the spacecraft's first uncrewed flight test with NASA's Space Launch System rocket, arrived at Kennedy Space Center in August. It was transported to the Shuttle Landing Facility, which is managed and operated by Space Florida, aboard NASA's Super Guppy aircraft.

The shipping container with the heat shield inside was offloaded and transported to the Neil Armstrong Operations and Checkout (O&C) Building high bay where technicians uncrated and secured it on a stand to begin the work to prepare it for Orion's next test flight, known as Exploration Mission-1 (EM-1).

"We are very excited the EM-1 heat shield has arrived here at the Orion factory on the first leg of a journey that will ultimately take it beyond the moon and back," said Scott Wilson, NASA manager of production operations for the Orion Program.

The heat shield was designed by the Lockheed Martin and NASA Orion team and built at the Lockheed Martin manufacturing facility near Denver. It is 16.4 feet wide (5 meters) in diameter, making it the largest of its kind.

The titanium truss structure has a composite substrate surrounding it. The heat shield will be capable of withstanding temperatures of up to 5,000 degrees F during Orion's re-entry into Earth's atmosphere.

"Arrival of the EM-1 heat shield structure at Kennedy marks a significant milestone that gets us one step closer to achieving NASA's ultimate goal, sending humans to Mars and returning them safely to Earth," said Jules Schneider, Lockheed Martin Orion KSC Operations senior manager.

In the O&C, technicians will apply the Avcoat, a type of thermal protection that wears away as it heats up (a process known as ablation), to the EM-1 heat shield in a different way than was done for Orion's 2014 flight test. Blocks of Avcoat will be bonded to the heat shield rather than filling individual honeycomb cells. The way the structure is attached to the crew module for the EM-1 heat shield has been simplified. Several different types of instrumentation also will be installed on the heat shield to gather data on heating and performance.

After the thermal protection system has been applied and inspected, engineers and technicians will put the heat shield through a thermal cycle test. The thermal cycle test ensures the thermal protection blocks are properly bonded and will perform as expected when they are exposed to the extreme temperatures during the mission. The heat shield will be attached to the Orion crew module in the summer of 2017.

During EM-1, Orion will travel farther than any spacecraft built for humans has flown before. It will travel thousands of miles past the moon and then return to Earth. During its three-week mission, engineers will monitor how Orion's systems perform in the environment of deep space and its return to Earth.

Orion is the spacecraft that will carry astronauts to deep-space destinations as NASA prepares for its journey to Mars. Orion will be equipped with power, communications and life support systems to sustain space travelers during their missions and return them safely to Earth.

A crane lifts the Orion heat shield for Exploration Mission 1 away from the base of its shipping container inside the Neil Armstrong Operations and Checkout Building high bay at Kennedy Space Center. The heat shield arrived aboard the agency's Super Guppy aircraft at the Shuttle Landing Facility on Aug. 26. The heat shield was moved onto a test stand to begin processing.
Photo credit: NASA/Dimitri Gerondidakis

For more information about Orion, visit:
www.nasa.gov/exploration/systems/orion/index.html

"This represents the hopes and dreams and blood, sweat and tears of thousands of people who have been working on this for years."

– Dante Lauretta
Principal Investigator for OSIRIS-REx at the University of Arizona

BENNU BOUND

Evening launch catapults OSIRIS-REx toward asteroid encounter

BY STEVEN SICELOFF

An Atlas V rocket traced a blazing arc into the Florida sky Thursday evening to send a small robotic explorer on its way to an asteroid on a mission that scientists anticipate will reveal answers to some of the basic questions about the solar system.

"Tonight is a night for celebration, we are on the way to an asteroid," said Ellen Stofan, NASA's chief scientist. "We're going to be answering some of the most fundamental questions that NASA works on."

Lifting off at 7:05 p.m. from Space Launch Complex 41 at Kennedy Space Center, the rocket's launch was timed to put the OSIRIS-REx spacecraft, short for Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer, on an exact course to reach the asteroid Bennu in August 2018.

Burning a combination of refined kerosene called RP-1 and liquid oxygen and carrying a single solid-fueled booster, the first stage of the United Launch Alliance Atlas V 411 pushed the spacecraft through the dense lower layers of the atmosphere, then the Centaur upper stage took over, propelling OSIRIS-REx faster and higher. About 55 minutes after launch, the asteroid sampling spacecraft separated from the liquid oxygen and liquid hydrogen fueled second stage rocket to fly free.

OSIRIS-REx will make a swing by Earth next year to gain a gravity assist that will accelerate it even faster to reach Bennu, where it will eventually go into orbit. Once orbiting the asteroid, OSIRIS-REx will spend two years surveying it in unprecedented detail.

Then, in a robotic first, the spacecraft will reach out its mechanical arm and take a sample from the asteroid. Though the sample will be small — only a couple of pounds at most — it will be a time capsule of sorts recording our solar system's creation. With the sample stored safely, the spacecraft will speed away from the asteroid on a path back to Earth.

"This represents the hopes and dreams and blood, sweat and tears of thousands of people who have been working on this for years," said Dante Lauretta, the principal investigator for OSIRIS-REx at the University of Arizona. "I can't tell you how thrilled I was this evening, thinking of the people who played a part in this."

Nearing Earth's atmosphere seven years from now, a capsule containing the sample and equipped with a heat shield will detach from the main OSIRIS-REx spacecraft and enter Earth's atmosphere. A parachute will slow the capsule down so it can be retrieved, then researchers will go about examining the precious cargo taken directly from an asteroid.

In earlier NASA missions, tiny samples of a comet and atoms collected from the solar wind have been taken and returned to Earth. Hundreds of pounds of rocks from the moon were returned to Earth by astronauts during six Apollo missions from 1969 to 1972. All these samples are curated by NASA's Johnson Space Center in Houston, which also will house the majority of material that OSIRIS-REx collects; a few percent of the sample will be sent for curation by international partners, the Canadian and Japanese space agencies.

This flight is the third of NASA's New Frontiers Program. The first two — New Horizons and Juno — already have made contributions to the study of the outer solar system and are still operating.

> ***"We keep hitting it out of the park and tonight we hit it off the planet."***
>
> **– Jim Green**
> **Director of NASA's Planetary Science division.**

"We keep hitting it out of the park and tonight we hit it off the planet," said Jim Green, director of NASA's Planetary Science division.

NASA's Launch Services Program, based at Kennedy, managed the launch for the agency. NASA's Goddard Space Flight Center in Greenbelt, Maryland will provide overall mission management, systems engineering and safety and mission assurance for OSIRIS-REx. Dante Lauretta is the mission's principal investigator at the University of Arizona. Lockheed Martin Space Systems in Denver built the spacecraft. OSIRIS-REx is the third mission in NASA's New Frontiers Program. NASA's Marshall Space Flight Center in Huntsville, Alabama, manages New Frontiers for the agency's Science Mission Directorate in Washington.

Watch the launch of the United Launch Alliance Atlas V rocket carrying NASA's Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer, or OSIRIS-REx spacecraft at: http://go.nasa.gov/2cIQ3GQ

A United Launch Alliance Atlas V rocket lifts off Sept. 8 from Space Launch Complex 41 at Cape Canaveral Air Force Station carrying NASA's Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer, or OSIRIS-REx spacecraft on the first U.S. mission to sample an asteroid, retrieve at least two ounces of surface material and return it to Earth for study.. The asteroid, Bennu, may hold clues to the origin of the solar system and the source of water and organic molecules found on Earth. Photo credit: NASA/Sandy Joseph and Tim Terry


TANDEMLOC
TANDEMLOC

A heavy-lift crane lowers the second half of the D-level work platforms, D north, for NASA's Space Launch System (SLS) rocket, into position Sept. 9 for installation in High Bay 3 in the Vehicle Assembly Building at Kennedy Space Center. The platform will be installed on the north side of the high bay. The D platforms are the seventh 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: Ben Smegelsky

TERRIFIC TURN

Student finds inspiration in NASA educational programs

BY BOB GRANATH

For Kristiana Rendón, studies in computer science led to multiple opportunities to apply what she is learning to educational programs at Kennedy Space Center. During the past year, she participated in the first annual Swarmathon and, later in the summer, the center's Launching to Learn program.

"Both were great experiences," Rendón said. "I think this helped me understand that software development really is my career goal."

Originally, computers were not her objective.

"After I received a bachelor's degree in psychology," said Rendón, "I planned on going into the medical field."

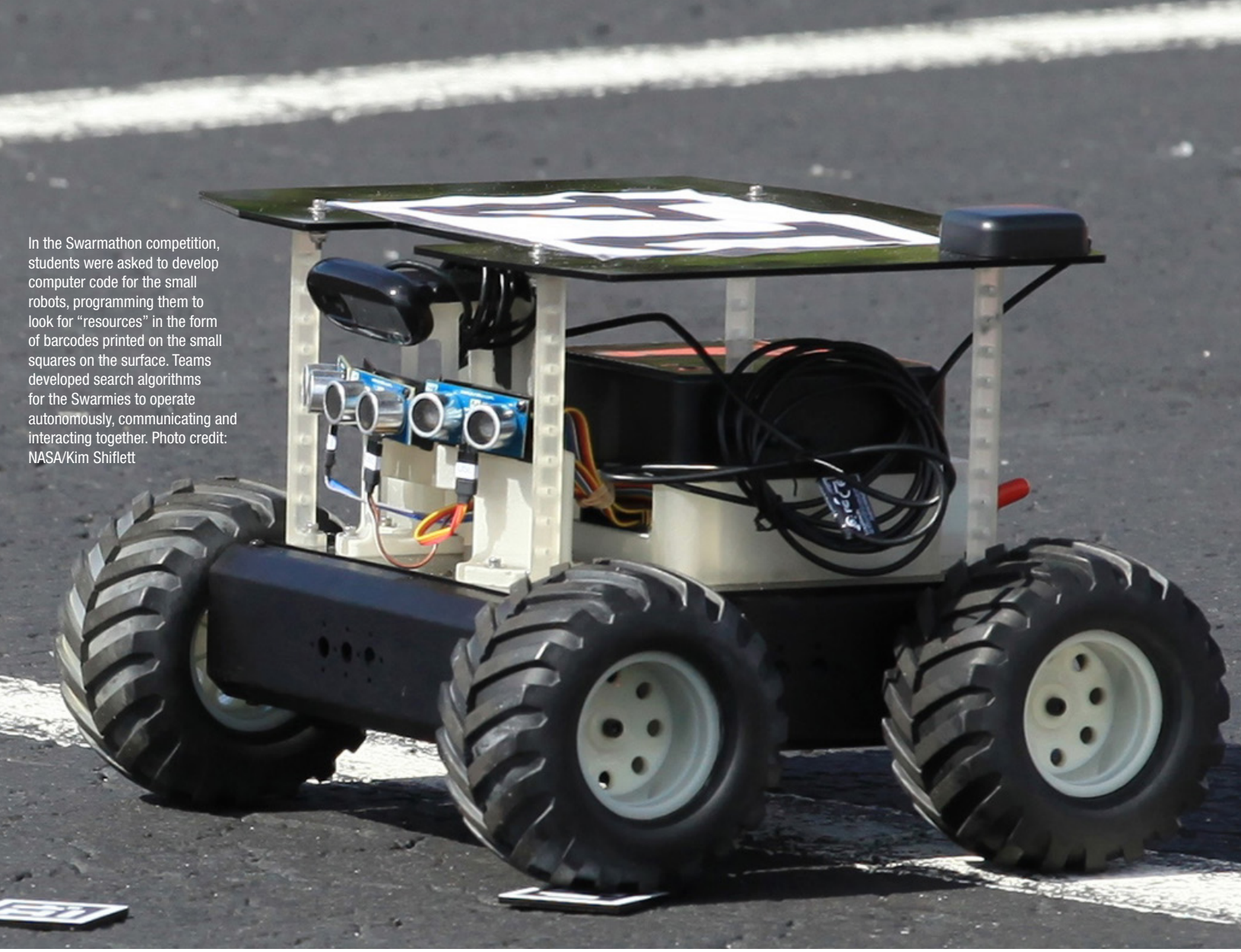
A Los Angeles native, Rendón graduated from the University of California, Riverside, in 2014, but changed directions as she began work on a master's degree.

"Last year, I took courses in computer science at Pasadena City College," she said. "My professor told us about an opportunity to participate in a NASA challenge to develop software codes and algorithms for small robots."

The small robots are known as "Swarmies." They look like small radio-controlled cars, but are designed to look for "resources" in the form of barcodes. In the future, similar devices may help find resources once astronauts land on Mars.

In the spaceport's first annual Swarmathon, students from 24 colleges and universities across the nation were selected to develop software code to operate these innovative robots. The event took place April 20-21, 2016, at the Kennedy visitor complex.

Kristiana Rendón with the first rocket she built as part of the Launching to Learn Program. Photo credit: Kristiana Rendón



In the Swarmathon competition, students were asked to develop computer code for the small robots, programming them to look for "resources" in the form of barcodes printed on the small squares on the surface. Teams developed search algorithms for the Swarmies to operate autonomously, communicating and interacting together. Photo credit: NASA/Kim Shiflett

For students such as Rendón and her team from Pasadena City College, participation in the Swarmathon helped improve skills in robotics, as well as in integrating hardware and software. NASA benefits as their developments help the agency refine technology for future human space exploration.

"We had several opportunities to interact with NASA experts in the computer field," Rendón said. "They not only helped us with our Swarmie robots, but gave us insights on how we can develop more advanced robotics in the fields of aerospace and spaceflight."

While the Swarmathon program focuses primarily on writing software code, requirements include reporting on how participants inspire younger students. Rendón explained that her team from Pasadena City College spoke to elementary and high school groups. Like NASA's educational programs, the aim is to encourage students to consider careers in science, technology, engineering and math, or STEM.

"We developed a challenge in which the students put a bucket over their heads before looking for candy on the floor," she said. "It helped them understand the challenges of a Swarmie looking for barcode or a robot on Mars looking for resources."

According to Theresa Martinez of Kennedy's Education Projects and Youth Engagement Office, Rendón's enthusiasm makes her a great ambassador, encouraging others.

"Kristiana's team did extremely well," she said. "Their outreach effort was led by Kristiana, and they won that category."

Martinez manages the Minority University Research and Education Project (MUREP) STEM Engagement activities.

In the Swarmathon competition, college and university teams developed search software for the small robots to operate autonomously. During the competition, the teams' algorithms operated the Swarmie robots in an official competition arena. Groups were ranked by the number of barcodes representing "resources" their Swarmie located in a specified period of time.

"We found that programing the Swarmies can be really difficult," Rendón said. "While it didn't go as well as we hoped, we learned a great deal from talking to students from other colleges and the NASA engineers who were there to assist."

Having spent time at Kennedy during the Swarmathon and given an opportunity to tour some of the center facilities, Rendón was eager to come back.

In the first annual Swarmathon competition at Kennedy Space Center, students were asked to develop computer code for the small robots. A team from Pasadena City College participated. Front row, from the left, are Jason Wang, Karen Chu, Sammi Lei, Alex Su and Kristiana Rendón. Back row, from the left, are Jamal Ashraf, professor of computer science, Kevin Macias, Stanley Chen, Anthony Guerra, Jarly Arciniega, David Wu and Kyle Dean. Photo credit: NASA/Bill White

"After the Swarmathon, I applied for Launching to Learn," she said. "I was thrilled when I was selected."

Starting on July 11, the Launching to Learn summer program guides college-level students in understanding concepts needed to develop rockets with guidance from experts at Kennedy.

"We started by each participant designing, building and launching a rocket," Rendón said.

The more complex task involved creating a more complex rocket in a team effort that introduced the students to many of the organizational concepts used by NASA.

"I was selected by my group to be our team leader," Rendón said. "That meant learning each person's strengths and weaknesses, then assigning tasks based on that. It helped us learn how people need to work as one."

It all comes together on launch day.

"Seeing our rocket lift off was awesome," Rendón said. "It really gives you a sense of accomplishment."

The Launching to Learn Program also included tours of numerous facilities at Kennedy and opportunities to hear from agency leaders.

"Meeting and hearing from experienced individuals at NASA was great," Rendón said. "They were always helpful and willing to answer our questions."

Rendón says her biggest takeaway from the two experiences was inspiration.

"It was not only encouraging, but gave me the motivation to keep working on a master's degree in computer science," she said. "Having the experience of just being at the Kennedy Space Center was really fun."

Martinez noted that she was impressed when Rendón came back to Kennedy for Launching to Learn.

"That kind of drive, along with her outgoing and warm personality makes her a standout student," she said. "I look forward to seeing her accomplishments as she continues her education."

In addition to pursuing interests in computer technology, Rendón enjoys reading, listening to music and outdoor activities, such as being an assistant SCUBA diving instructor. She also plays saxophone in the marching and concert bands at Pasadena Community College.

"I was in the Tournament of Roses Parade Honor Band," she said.

After Rendón earns her degree, would she like to work for NASA?

A 7-mile drive north of her college campus is NASA's Jet Propulsion Laboratory, the leading agency center for robotic exploration of the solar system.

"Working at JPL or any NASA center would be really amazing," she said. "I've been networking and connecting with people I've met at NASA. I think my experiences at Kennedy will definitely help open doors for me in the future."

Making the Grade

Kennedy team welcomes report of Juno's progress

BY ANNA HEINEY

Since its arrival in orbit around Jupiter nearly three months ago, the Juno spacecraft already is impressing scientists with its observations of the gas giant. Employees at Kennedy Space Center were briefed Sept. 20 on the status and the scientific promise of a mission many audience members helped launch a little more than five years ago.

"Of course, what we're really after is to learn about Jupiter — which is helping us to learn about ourselves," said Scott Bolton, principal investigator for Juno at the Southwest Research Institute in San Antonio, Texas.

Kennedy's Launch Services Program led the successful launch of Juno aboard a United Launch Alliance Atlas V rocket from Cape Canaveral Air Force Station. After some deep-space maneuvers in 2012 and an Earth flyby that provided a gravity assist in October 2013, Juno arrived at the largest planet in our solar system on July 4, 2016.

Jupiter was the first planet to form after the sun, Bolton explained. A better understanding of Jupiter's makeup could help provide the "recipe" for a solar system.

"The stuff that Jupiter has more of than the sun — that's what we are made of," he explained.

Juno took 53 days to go around on the first orbit and it passed by Jupiter on Aug. 27 — this time for the first time with the science instruments on. The photo was taken as Juno closed in on Jupiter's north pole.

After another 53 days, around Oct. 19, the spacecraft will perform its final burn to place Juno into a 14-day "science orbit" from which it will begin regularly mapping the gas giant.

Juno has come a long way since its departure from Earth.

"On Aug. 5, 2011, we launched from here. I'm so indebted to all of you, and everybody here at Kennedy who worked with you, because I realized when I got that close to it and was responsible for Juno just how difficult the launch was," Bolton said.

"It is an immense amount of work and engineering challenge. What you do here is incredible."

Juno will continue to orbit and study Jupiter until the spacecraft's scheduled deorbit into the planet in February 2018.

As NASA's Juno spacecraft closed in on Jupiter for its Aug. 27 pass, its view grew sharper and fine details in the north polar region became increasingly visible.
Photo credit: NASA/JPL-Caltech/SwRI/MSSS

Inset: NASA's Juno spacecraft launches aboard a United Launch Alliance Atlas V rocket Aug. 5.
Photo credit: NASA/Tony Gray and Don Kight

With the lights out, team members perform an optics test on the Advanced Baseline Imager, the primary optical instrument, on the Geostationary Operational Environmental Satellite (GOES-R) on Aug. 31 inside the Astrotech payload processing facility in Titusville, Florida near Kennedy Space Center. Carbon dioxide is sprayed on the imager to clean it and test its sensitivity. GOES-R will be the first satellite in a series of next-generation NOAA GOES Satellites. The spacecraft is to launch aboard a United Launch Alliance Atlas V rocket in November.
Photo credit: NASA/Ben Smegelsky

Our Refuge

NASA'S KENNEDY SPACE CENTER NATIONAL WILDLIFE REFUGE

Since August of 1963, Kennedy Space Center has coexisted with Merritt Island's National Wildlife Refuge. Just south of Launch Pad 39A, manatees graze protected in a sanctuary in the northern end of the Banana River. Between May and September, thousands of endangered sea turtles come ashore on this barrier island in the dark of night to lay their eggs. Merritt Island's strategic location along the Atlantic Flyway provides a resting and feeding place for thousands of ducks, wading birds, shorebirds and songbirds. Diverse habitats that include brackish marshes, salt water estuaries, hardwood hammocks and upland scrub provide homes to an amazing diversity of more than 500 species of fish and wildlife, including many that are protected under the Endangered Species Act. Today, these 220 square miles are managed by the Department of the Interior as a national wildlife refuge and national seashore with the exception of about 10 square miles dedicated to the launch, landing and processing facilities that support the space program. In this Q&A series about responsibilities of the KSC Ecological Program, we provide knowledge surrounding climate change and its impacts to Kennedy. Included are the monitoring activities, explanations of climate change verbiage, and a quick synopsis of the extremes that Earth has endured. Remember, it is all of our responsibility to leave this planet in better shape for the future generations than we found it.

Climate Change

Question: How extreme has climate been?

Answer: Throughout the 4.6 billion year history of the Earth, the climate has gone through many extremes as the planet has evolved from a hot-lifeless molten mass in the Hadean epoch more than 4 billion years ago, to the last frozen snowball Earth about 700 million years ago, to the moderate ice age of the last 2 million years. These changes occurred over long time scales of tens of thousands to millions of years as the result of changing solar output, meteor bombardment, orbital dynamics, plate tectonics, volcanic activity, weathering of rocks, and biological activity.

Q: What is a greenhouse gas?

A: A greenhouse gas is any gaseous compound, CO2 for example, in the atmosphere that is capable of absorbing infrared radiation, thereby trapping and holding heat in the atmosphere. By increasing the heat in the atmosphere, greenhouse gases are responsible for the greenhouse effect, which ultimately leads to global warming.

Q: Climate is always changing. Why is this time different?

A: During the last 600 million years or so large amounts of CO2, a known greenhouse gas, was captured and sequestered as fossil fuels (e.g. natural gas, oil and coal). This natural process of sequestering carbon reduced atmospheric concentrations of CO2 to less than 300 parts per million, producing a somewhat stable climate environment that allowed for the development of agriculture as a way of life. Since the onset of the industrial revolution, in the late 1800s, the planet has experienced a human population explosion that has exceeded 7 billion individuals. This rapid growth has been made possible by the burning of fossil fuels and other actions releasing around 38 gigatons of CO2 per year, to produce the foods and commodities required to support the human race. In 2013, atmospheric CO2 concentrations passed the 400 ppm mark for the first time in 800,000 years. This increasing trend in the CO2 greenhouse effect makes this round of climate change different from all significant events in the past. In addition, many of our major ports and cities are located at the current sea level. Recent studies suggest if CO2 emissions go unchecked, melting of major ice sheets in Greenland and Antarctica could raise sea level by more than 70 feet during the next several hundred years.

Q: How are NASA scientists monitoring climate change?

A: NASA is recognized worldwide as a leader in Earth sciences and climate change monitoring and research. NASA scientists utilize an array of satellite remote sensing tools to monitor the climate and climate change affects. One system, the Gravity Retrieval and Climate Experiment (GRACE), can measure changes in the Earth's

gravity field as a function of water movement. This system can detect the ice loss in Greenland and Antarctica as well as the loss of soil moisture from the California drought. A second system, the Jason altimeters, are used to measure changes in sea level around the globe, while the Orbiting Carbon Observatory (OCO2) is used to monitor human emissions and natural fluxes of carbon dioxide on a real time basis. NASA data scientists utilize complex global circulation models (GCMs) running on advanced super computers to simulate future climate conditions incorporating, where possible, satellite and ground based measurements to reduce uncertainty. The models are tested by simulating past climate conditions and effects of events such as volcanic eruptions.
https://www.youtube.com/watch?v=x1SgmFa0r04

Q: What is NASA doing to prepare for climate change across the agency and Kennedy?

A: To prepare the agency for effects of climate change, the NASA HQ Offices of Strategic Infrastructure and Earth Sciences created the Climate Adaptation Science Investigators (CASI) program. The goal of the program is to incorporate climate change data and knowledge into the planning and operations decision making processes required to meet the NASA mission at each center. Climate change related issues are based on local conditions and current forecasts provided by the Goddard Institute for Space Studies (GISS). At Kennedy, the data are is used by Master Planning, Construction of Facilities, the Engineering Construction and Innovation Committee, the Environmental Planning Branch, U.S. Fish and Wildlife Service (USFWS), and others concerned with facilities, infrastructure and natural resources. Kennedy scientists are investigating how climate change might impact sustainability, emerging contaminants, and local ecosystem services and engineers are assessing potential impacts to facilities, infrastructure and operations. All of these activities are focused on maximizing the use of center resources in support of the NASA mission.

Q: What is the difference between climate and weather?

A: The difference between weather and climate is related to the time scale of measurement. Weather can change rapidly from hour to hour, day to day or month to month. Climate is the long term (30-1,000 year) average of weather conditions. At Kennedy, our daily weather is a function of being located in a transition zone between the temperate climate of Georgia and the Carolinas and the sub-tropical climate of the Caribbean Islands. We have infrequent freezing weather and routine summer thunderstorms. Climate change forecast indicate a shift to the more sub-tropical climate with increases in the number of days above 90o F, fewer days below 40o F and more dry weather in winter months with the passage of fewer cold fronts.

Q: What are some of the measurable signs that climate change is occurring now?

A: During the last 20 years, the Atlantic Ocean and the Indian River Lagoon have risen almost 4 inches as measured at the U.S. Geological Survey (USGS) Haulover Canal water level meter and the NOAA tide gauge in Port Canaveral. Furthermore, due to the lack of freezing weather, Mangrove trees, Brazilian Pepper, and other tropical species such as tilapia and lionfish have extended their ranges northward.

Q: How are climate change forecasts made and how are they tested?

A: Climate change forecast are made using global circulation computer models (GCMs) that couple atmosphere-ocean circulation models to simulate the Earth's climate system. At Kennedy, we are primarily involved with the climate modeling program at GISS and the Columbia University Earth Institute. GCMs take into account factors such as clouds, volcanic eruptions, human emissions, deforestation, agriculture, atmospheric aerosols, solar insolation, ocean currents, and numerous other parameters. Model simulations can be run for past, current and future conditions. The models are tested by comparing their ability to simulate recent conditions and events such a volcanic eruptions with observed empirical data. An extensive testing process involving 20 climate modeling groups from around the world was established in 2008 to address 1) how realistically models simulate the recent past, 2) to develop near term (2035) and long term (2100 and beyond) projections and 3) to understand difference in the various GCM projections involving clouds and carbon cycling.

Q: Kennedy and the overlay Merritt Island National Wildlife Refuge are home to many protected species of wildlife. What are the possible effects of climate change on these populations?

A: Climate change at Kennedy has the potential to significantly impact species of special concern. In the low lying coastal environment, plant community distributions and associated wildlife habitats are directly related to depth to the water table. Kennedy has an average elevation of about 2.3 feet. Rising sea levels will flood low lying wetland areas around the center and wetlands will become established at higher elevations. The Environmental Protection Agency (EPA) Sea Level Affecting Marshes Model (SLAMM) has been used to assess potential changes. SLAMM's output suggests most salt marshes also will be converted to mangrove in the absence of freezing temperatures. As water levels continue to rise, upland communities will transition to types that are adapted to shallower water tables. This will impact the distribution and quality of Kennedy's scrub ecosystem that supports species such as the Florid Scrub Jay, indigo snakes, and gopher tortoises. Rising sea levels also will impact the sea turtle nesting beaches and the coastal strand, home to the protected southeastern beach mouse.

A group of U.S. Navy divers, Air Force pararescuemen and Coast Guard rescue swimmers practice Orion underway recovery techniques in the Neutral Buoyancy Laboratory at NASA's Johnson Space Center in Houston on Sept. 21. The uncrewed Orion spacecraft will splashdown in the Pacific Ocean off the San Diego coast at the end of its test flight with the agency's Space Launch System (SLS) rocket during Exploration Mission 1 (EM-1). EM-1, Orion's first flight atop the SLS, will pave the way for future missions with astronauts and help NASA prepare for missions to Mars. Photo Credit: NASA/Radislav Sinyak

National Aeronautics and Space Administration

John F. Kennedy Space Center
Kennedy Space Center, FL 32899

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