The top five things we will learn from Exploration Flight Test-1

By Brandi Dean

ALL THE SUPERLATIVES associated with Orion's first mission this year—farthest a spacecraft for humans has gone in 40 years, largest heat shield, safest vehicle ever built—can be dazzling, no doubt. But the reason engineers are champing at the bit for this first mission is the promise of crucial flight test data that can be applied to the design for future missions.

NASA/RAD SINYAK

The Orion crew module for Exploration Flight Test-1 is shown in the Final Assembly and System Testing (FAST) cell, positioned over the service module just prior to mating the two sections together. The FAST cell is where the integrated crew and service modules are put through their final system tests prior to rolling out of the Operations and Checkout Building at NASA's Kennedy Space Center in Florida for integration with its rocket.

Orion only has two flight test opportunities before astronauts climb aboard on Exploration Mission-2 in 2021, so gleaning the maximum information possible from Exploration Flight Test-1 (EFT-1) in December (and later, Exploration Mission-1 in 2017) is of the highest priority. Here are the top five things the engineers will be paying attention to:

RADIATION LEVELS

Traveling 15 times farther into space than the International Space Station will take Orion beyond the radiation protection offered by Earth's atmosphere and magnetic field. In fact, the majority of EFT-1 will take place inside the Van Allen Belts, clouds of heavy radiation that surround Earth. No spacecraft built for humans has passed through the Van Allen Belts since the Apollo missions, and even those only passed through the belts—they didn't linger.

Future crews don't plan to spend more time than necessary inside the Van Allen Belts either, but long missions to deep space will expose them to more radiation than astronauts have ever dealt with before. EFT-1's extended stay in the Van Allen Belts offers a unique opportunity to see how Orion's shielding will hold up to it. Sensors will record the peak radiation seen during the flight, as well as radiation levels throughout the flight, which can be mapped back to geographic hot spots.

COMPUTER FUNCTION

Orion's computer is the first of its kind to be flown in space. It can process 480 million instructions per second. That's 25 times faster than the International Space Station's computers, 400 times faster than the space shuttle's computers and 4,000 times faster than Apollo's.

But to operate in space, it has to be able to handle extreme heat and cold, heavy radiation and the intense vibrations of launches, aborts and landings. And, it has to operate through all of that without a single mistake. Just restarting the computer would take 15 seconds. While that might sound lightning fast compared to your personal computer, you can cover a lot of ground in 15 seconds when you're strapped to a rocket.

PHOTO: LOCKHEED MARTIN

Technicians work inside the Orion crew module being built at Kennedy Space Center to prepare it for its first power on. Turning the avionics system inside the capsule on for the first time marks a major milestone in Orion's final year of preparations before its first mission, EFT-1.

HEAT SHIELD PROTECTION

Before the parachutes even get a chance to deploy, Orion has to make it safely through Earth's atmosphere. The reason that Orion is traveling so far and coming back in so fast is to give the heat shield a good workout. The idea is to get as close as possible to the temperatures Orion would experience during a return from Mars. At the speed it will be traveling, the temperature should reach almost 4,000 degrees Fahrenheit. At that same temperature, a nuclear reactor would melt down.

Standing between the crew module and all that heat is no more than 1.6 inches of Avcoat, a material that's designed to burn away rather than transfer the temperatures back to Orion. Some 20 percent of the Avcoat will erode during the spacecraft's journey back to Earth. And although it's not the first time the materials have been used for this

purpose, at 16.5 feet wide, Orion's heat shield is the largest ever built. Technicians filled with Avcoat each of the 320,000 honeycomb cells with that make up the shield's structure by hand, and then machined them to the precise fractions of inches called for by the design. Getting it exactly right is all that will get Orion through one of the most dynamic periods of its mission.

NASA/NASA/DANIEL CASPER

Engineers completed installing the heat shield on NASA's Orion spacecraft ahead of its first trip to space in December. The heat shield will help protect the Orion crew vehicle from temperatures of about 4,000 degrees Fahrenheit during its re-entry into Earth's atmosphere.

PARACHUTE DEPLOYMENT

Speaking of parachutes … for EFT-1, Orion will travel 3,600 miles above the Earth. So when it performs its deorbit burn, it will come screaming back into the Earth's atmosphere at almost 20,000 mph. Before it splashes down in the Pacific Ocean, Orion will slow down to 1/1000th of its entry speed to a relatively gentle 20 mph.

Earth's atmosphere does its part to put on the brakes, but to make landing survivable, Orion relies on its parachute system—primarily two drogue parachutes and three massive mains that, together, would cover almost an entire football field. They've been tested on Earth; test versions of Orion have been dropped from airplanes with a multitude of failure scenarios programmed into the parachute deployment sequence in an effort to make sure that every possibly problem is accounted for. A total of 17 of these tests are planned.

But the sheer number of possible problems to be tested indicates how complicated the system is. Each parachute must deploy at the exact right time, open to the exact right percentages in the exact right stages, and be cut away exactly as planned. And no test on Earth can exactly simulate what the spacecraft will really experience on its return from space.

NASA/PHOTO

Orion floats to the ground in during one of its many drop tests, showing off the full capability of its parachute system.

LAUNCH ABORT SYSTEM SEPARATION

The Launch Abort System (LAS) is a key reason that Orion is intended to become the safest spacecraft ever built. In an emergency, it could activate to pull the crew module and the astronauts it will carry away from the launch pad and the rocket in milliseconds. Hopefully it's never needed, but since no crew will fly on EFT-1, the rescue system won't be active.

But even when a launch goes perfectly, the 904-pound LAS jettison motor has to perform flawlessly. If it doesn't get rid of the LAS six minutes and 20 seconds into the mission, there will be no landing. The LAS protects the crew module during ascent—but to do so, it blocks the parachutes that allow Orion to safely splashdown.

The Launch Abort System separation is just the first of 17 separations, or jettisons, that have to happen exactly as planned for the mission to be successful.

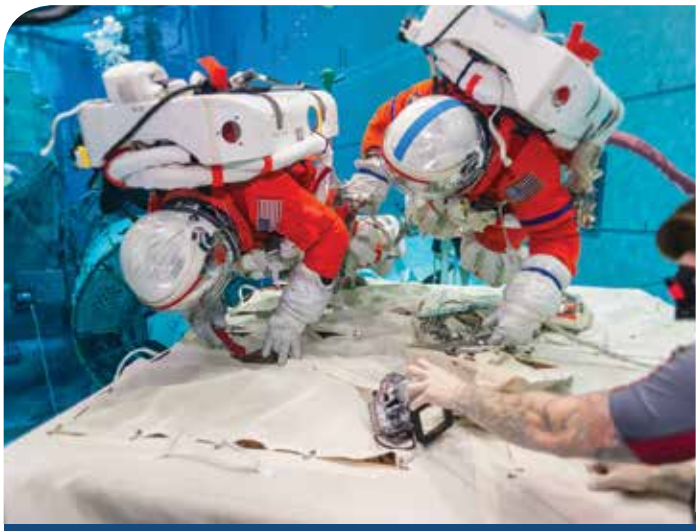
NASA/PHOTO

The Orion launch abort system lifts off during the Pad Abort 1 flight test on May 6, 2010, at the White Sands Missile Range.

Astronauts demonstrate they are well 'suited' for **exploring asteroids**

By Mark Carreau

TWO ASTRONAUTS GARBED in the Modified Advanced Crew Escape Suit (MACES) submerged themselves in the waters of the Neutral Buoyancy Lab (NBL) to successfully demonstrate the distinctive orange garment borrowed from NASA's Space Shuttle Program will support spacewalk objectives of NASA's Asteroid Redirect Crewed Mission.



NASA/BILL BRASSARD JSC2014E044907

Astronaut Stan Love cuts open a mock-up of an asteroid capture inflatable bag while astronaut Steve Bowen assists.

During the four-hour May 9 asteroid simulation, astronauts Stan Love and Steve Bowen crawled from the side hatch of their Orion capsule mock-up, hocked an extension boom to the docked asteroid redirect vehicle and translated hand over hand to the inflatable structure encapsulating their prized near-Earth object to gather rock samples.

"This test told us that absolutely we feel confident we can do this mission," said Jonathan Bowie, NASA's Asteroid Redirect Crewed Mission Extravehicular Activity (EVA) project lead. "We have had good evidence to say we think we can. Now, we have evidence that says 'I know I can do this."

Bowie and a 20-member team from the Engineering and Mission Operations Directorates began working toward the asteroid demonstration last year.

"It's just a matter now of getting our procedures to where they are the most efficient—best for the crews, best for the scientists," Bowie said. "But from just a first order: Can we do it? Yes, we can."

The actual Asteroid Redirect Mission begins with the launching of a robotic spacecraft to capture a small asteroid, or a boulder from a larger asteroid. Once enclosed in a high-strength inflatable bag, the asteroid will be steered by the redirect vehicle into a stable, distant retrograde orbit around the moon. In the mid-2020s, an Orion spacecraft with two astronauts will embark on a mission to rendezvous with the asteroid and return samples to Earth.

Love and Bowen, building on earlier NBL simulations by astronauts Dan Burbank and Rex Walheim, completed their NBL sample collecting and repeated the tasks—all within four hours, the time originally set aside for a single run.

"The biggest unknown for going out and doing a spacewalk on a captured asteroid is what the asteroid is going to be like," said Love, an astronomer and asteroid expert. "The small asteroids we can get with a robot ship are tiny. They are few yards across. Even in the world's finest telescopes, they are a dot. So we are exploring what we can here in the NBL so that on the real day, we will have a better chance of doing it correctly."

Efforts to convert the Advanced Crew Escape Suit (ACES), the pressure garment that astronauts donned before the launch and re-entry phases of most shuttle missions, began last year. The goal was to modify ACES so the suit could play the same role during Orion missions, as well as provide protection during spacewalks for external repairs.

Satisfied MACES could handle those tasks, Bowie's team altered the sleeves of the suits, initially tailored so astronauts could reach out to cockpit instrumentation. The sleeve angle was adjusted and a bearing added at the shoulders so the astronauts could extend their arms to a work area just beyond their helmet visors.

The alternations eased the way May 6, as Love and Bowen first cut into the inflatable bag surrounding a simulated asteroid and used a pneumatic hammer and chisel to collect and store samples.

The modified suits were also enhanced with gloves and boots borrowed from Extravehicular Mobility Units, or spacesuits worn by astronauts during spacewalks outside the International Space Station. Those and a change to the Portable Life Support System backpack allowed Love and Bowen to anchor themselves to the extension boom and handholds on the asteroid redirect vehicle using body restraint tethers and foot restraints.

After 13 NBL runs in the past year, there's still more ahead for MACES.

Priorities include improving the fit of the suit in its launch and re-entry phases, as well as spacewalk configurations. The first must be somewhat loose for comfort inside Orion, and the second snug for ease in working outside.

"Next, we go back in the lab to see how we can make things even better," Bowie said. "Getting those two things to work together at the same time will be our next challenge."

NASA/BILL BRASSARD JSC2014E044913

Using a soft cloth, Love picks up a geologic sample and prepares to place it into a sample container.

Communications accessories show that function trumps fashion when it comes to wearable technology

By Mark Carreau

"IS THAT MY SLEEVE CALLING?"

"Could it be the temperature sensor in the new plant growth chamber? Perhaps it's a CO2 monitor in the airlock. Maybe it's personal—have I forgotten someone's birthday?"

Connectivity: You can't thrive without it these days, and tomorrow's version of electronic interaction promises to make even the latest smartphone and rise of wireless networks seem cumbersome.

For three years, the Wearable Technology Symposium hosted by NASA's Johnson Space Center has challenged college students from some of the nation's top industrial design, computer science and engineering programs to help shape that vision. How might small crews of astronauts living aboard the International Space Station, or someday exploring far from Earth, meet demands for greater efficiency and safety in space operations?

The E-SEWT, short for Electronic-textile System for the Evaluation of Wearable Technology, offers a promising approach—one that combines functional clothing with electronics to achieve the most in multitasking through hands-free communications.

"This is more than product design. This is interaction design plus product design," explained Cody Miller, a junior industrial design major from New York's Pratt Institute and one of those enthusiastic about addressing the challenge at the 2014 symposium. He and classmate Kai Lin envision the use of 3-D printing, another emerging technology that has piqued NASA's interest, for the fabrication of small hexagonal plastic blocks embedded with an assortment of custom electronics for audible, tactile and text-enabled displays.

The swatches, as these prototype communications accessories are known in the fashion industry, could be fastened by astronauts to lightweight fabric E-SEWT vests, belts or sleeves worn over their everyday shirts and pants. That allows the normal clothing to be laundered or discarded. Swatches allow for a wide range of function and choice in the selection of wearable devices as well.

"We wanted to incorporate 3-D printing because it's so versatile," Lin said. "It's a unique platform to make a tactile warning device, or one for audible alerts or something visual like text. You can keep your mind and your eyes focused on the task at hand while relying on these sensors to provide information about the other things you are responsible for."

NASA/NASA/BILL STAFFORD AND CRYSTAL SCHROEDER JSC2014E037699

Pratt Institute student Cody Miller discusses his team's prototype E-SEWT using 3-D-printed swatches with Virginia Tech student Gabriella Jacobsen at the 2014 Wearable Technology Symposium.

PHOTO/REBECCA PAILES-FRIEDMAN, PRATT INSTITUTE

Pratt Institute student Yun Jin Kim tests a wearable circuit integrated into a garment for her team's redesigned E-SEWT.

Fellow Pratt junior Violet Tamayo presented an alternate approach, an all-fabric modular E-SEWT with vest, belt and sleeves tailored for women and men.

"We rely on user-oriented software so you can customize our approach based on your needs," Tamayo said. "A big part of our work was deciding how to make our approach work for you without conformity."

Like the 3-D approach, the unisex styling allows the wearer to select from audible alert swatches to draw attention to the most urgent matters, a tactile version that vibrates in response to something less pressing or a visual display for more casual text communications.

Since the first symposium in 2012, the annual gathering has grown from one to five schools, 22 to 100 student participants and six to 23 projects that address technology needs ranging from radiation shielding to jet-pack controls.

Each was chosen to help address NASA's future technology needs, said symposium organizer Cory Simon, a member of JSC's Human Interface Branch and an E-SEWT architect. Each project has NASA mentors.

Students from Pratt and Texas A&M were new to the symposium this year, rounding out participation from the University of Minnesota, Georgia Tech and Virginia Tech.

"All we do has to have relevance on Earth," Kamlesh Lulla, Ph.D., director of the University Research, Collaborations and Partnership Office at JSC, told students gathered for the 2014 symposium on April 21. "What we do through these projects certainly is useful to us at NASA, because it has relevance to how we improve life on Earth."

Message received.

"This is a big step for planning efficiency, safety and productivity in all fields," Miller said. "It does not have to be for an astronaut. My brother is a firefighter. This wearable tech, especially from a 3-D printer, can be anything. It could be a sensor that clips onto the boot to provide a warning when things get too hot."

"This opportunity has completely opened my eyes," Tamayo added. "I really want to pursue the integration of something wearable, fashionable, that functions with a serious purpose."

Simon said of the students, "They work their tails off and consistently provide some very good results. We're able to leverage their creativity, their fresh perspectives."

Spotlight: **Lauren Harnett**

Scientific Photographer with DB Consulting Group, Inc.

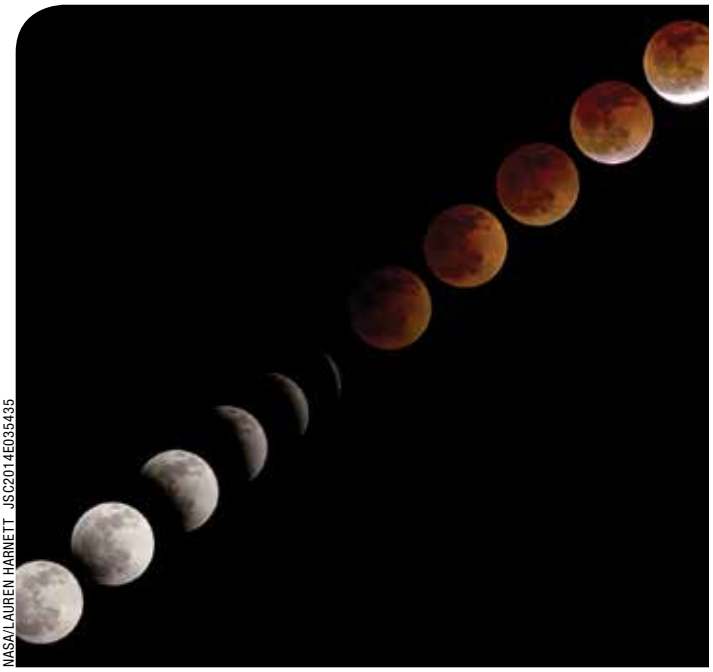
Q: Coolest part of your job at Johnson Space Center?
A: One of the greatest aspects of being a photographer/videographer at NASA is that all of JSC is my office. A multitude of projects, experiments and trainings happen continuously and simultaneously all over campus. Each day my assignments bring interesting and diverse opportunities and challenges, and I get to meet and work with a wide range of professionals.

Q: Who has been inspirational to you, and why?
A: My Mom and Dad have been huge sources of inspiration. Both were government employees who taught me about dedication, commitment and trying your best, in addition to fighting for what you believe in. Now, in retirement, they continue to inspire me with the ways they get involved, stay busy and "give back" to the community by participating in volunteer projects, activities and committees.

Q: What would people be surprised to know about you?
A: I am an avid snowboarder, which is why I moved from the northeast to Houston, where the mountains are many and the snow is plentiful.

Q: If you could trade places with any other person for a week, famous or not famous, living or dead, real or fictional, who would it be?
A: Mary Joyce, who was born in 1899. She was the first female radio operator in Alaska and became one of the first female pilots in Juneau. And, in 1935 at the age of 37, she embarked on a three-month, 1,000-mile dog sled trek from Juneau to Fairbanks, sometimes alone, sometimes with a guide, along mostly unmapped territory because she "wanted to see the country and experience some of the things the old-timers did. [She] just wanted to see if [she] could do it." She was an amazing woman who didn't let gender bias stop her from successfully pursuing her goals and aspirations.

Q: What is your favorite indulgence?
A: Well, I have a bit of a weakness for popcorn …



NASA/LAUREN HARNETT JSC2014E035435

NASA/PHOTO JSC2014E054534

Q: As a professional photographer, what kind of photos do you enjoy taking the most?
A: I love to photograph the natural world: plants, animals and landscapes. I've also been known to photograph the moon once or twice …

Q: Where do you dream of vacationing one day?
A: The world is too vast to narrow my dreaming to one location.

Q: Describe yourself in three words.
A: Batty for bats.

Q: What is the best piece of advice you freely hand out?
A: "Every day is a good day for Chinese food."

Q: When did you first become interested in space, and why?
A: I first became interested in space in elementary school, when my uncle gave me a glow-in-the-dark mobile of the planets with sticker stars that I hung from my bedroom ceiling. When I was older I painted my room yellow and blue and spent considerable time attaching glow stars to the ceiling, walls and even to strings that I hung from the ceiling to represent "shooting stars." I had my very own planetarium! When I inherited my parents' old truck in high school, I painted the truck bed cap with a sunrise on one side and a nightscape with stars on the other. Space is fascinating!

Q: What is your favorite memory at JSC or of the space program?
A: The shuttle years were among my favorite at NASA. The shuttle was such an impressive vehicle, and the atmosphere on-site was uplifting and positive. The opportunity to support Space Flight Awareness activities in Florida for the STS-135 launch, and being there to witness the launch in person, ranks pretty high on my favorite NASA memories list.

Q: What is NASA currently doing that has you most excited?
A: The different simulated missions NASA runs to study the effects on the human mind and body while living in a confined environment are fascinating. These simulations, including NASA Extreme Environment Mission Operations, Desert Research and Technology Studies and the Human Exploration Research Analog, are also used to help develop, test and refine hardware, protocols and procedures that would be used on a real mission to space, the moon or another planetary body.

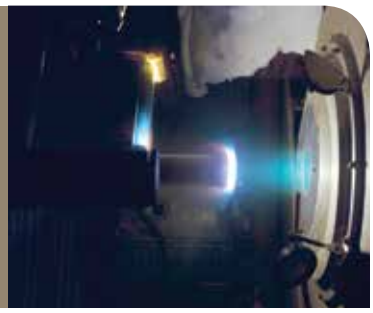
Johnson Space Center remembers the Arc Jet facilities, history

FROM ITS OPENING in September 1963 until its last test run on March 21, Johnson Space Center's "Arc Jet" facilities were used extensively as hands-on, enclosed fire-breathing labs where engineers gathered to recreate the extreme high-temperature air flows that spacecraft as different as Apollo and the space shuttle confronted to deliver their passengers safely back to Earth.

NASA/JAMES BLAIR JSC2014E027347

The Arc Jet team poses for a photo at the last test run on March 21.

Reinforced Carbon Carbon is tested with the fire-breathing properties of the Arc Jet Facility, exposing the material to extreme heating conditions.



NASA/PHOTO BLAIR S90-28828

"We simply could not have carried out human spaceflight without the capability of the Arc Jet and the expertise of the people who have staffed it over the years," said JSC Director Ellen Ochoa. "Regardless of where the hardware is, we'll continue to need that expertise to address the safety of crews returning from space and other exploration activities."

As the labs evolved, the primary requirement for the facilities clustered in the center's northeast quadrant was always the same: to demonstrate the ruggedness of heat shielding and help to "human rate" a succession of NASA spacecraft, from Apollo and shuttle to the emerging Orion and Commercial Crew Program vehicles.

As JSC bids adieu to these remarkable labs, read more in JSC Features at http://go.usa.gov/8SXm about how by recreating tempestuous conditions in space, our professionals contributed to past, present and future human missions.

Have you seen it through the great Vine?

NASA ASTRONAUT REID WISEMAN, flight engineer for Expedition 40/41, launched to the International Space Station on May 29 and has been sharing incredible photos from space to his Twitter account, @astro_reid, since. A highlight for his posts happened June 6 when he made history by posting the first Vine video from space.

If you haven't heard of it yet, Vine is a mobile app that enables its users to create and post short looping video clips. Video clips created with Vine have a maximum length of six seconds and can be shared to Vine's social network or to other services such as Twitter and Facebook.

The post has been retweeted more than 5,000 times (and counting), giving a total audience of more than 50 million the opportunity to see it. The official Vine account, which has more than 10 million followers, retweeted @astro_reid, along with *ABC News, USA Today* and several other notable sources.

Though it's really tough to outdo the majesty of the Earth, Wiseman's most recent Vine features his crew mate, Alexander Gerst of the European Space Agency, working with the Minus Eighty-Degree Laboratory Freezer aboard the International Space Station.

Check out these popular Vines and join in on the social media fun with NASA:
https://vine.co/v/MD1eEQEjM9u
https://vine.co/v/Mj9Dz3zKtJM

NASA /PHOTO

An Expedition 40 crew member aboard the International Space Station photographed this view of a sun-kissed solar array wing and a photovoltaic radiator (top) on the orbital outpost on June 3.

Roundup

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Pioneering space—**the best is yet to come**

FOR SOME, IT SEEMS LIKE ONLY YESTERDAY when spacesuited boots kicked up dust on the moon: July 20, 1969, to be precise. Forty-five years later, instead of a sapphire to commemorate this special occasion, NASA wants something more.

Forget jewels. Johnson Space Center is on a path to Mars, and we won't rest until explorers are free from the bonds of low-Earth orbit. The moon was just the beginning. For JSC, the next steps include:

- Getting reliable and affordable rides into low-Earth orbit courtesy of the ingenuity of U.S. companies
- Mastering low-Earth orbit and long-duration missions with the International Space Station
- Breaking free from low-Earth orbit with Orion and the Space Launch System
- Pushing farther into cis-lunar space
- Planetary independence by exploring the Red Planet, its moons and other exotic, deep-space destinations that tempt the human imagination

Is your interest piqued? Learn more by visiting JSC's 2.0 website, where you'll find a calendar with more Future of Exploration series events, plus charts that explain, in depth, our path to the Red Planet: http://go.usa.gov/8SQ9

On June 5, a special panel at JSC discussed "Pioneering Space: The Next Steps on the Path to Mars" with (from left) JSC Director Ellen Ochoa; NASA Associate Administrator for Human Exploration and Operations Bill Gerstenmaier; Orion/Multi-Purpose Crew Vehicle Manager Mark Geyer; JSC Deputy Director Kirk Shireman; Engineering Director Lauri Hansen; and Engineering Deputy Director Steve Stich.

NASA/MARK SOWA JSC2014E057496