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Marshall Center Engineers Push the Limits of 3-D Printing Technology

NASA engineers have successfully tested the most complex rocket engine parts ever designed by the agency and printed with additive manufacturing, or 3-D printing, on a test stand at NASA's Marshall Space Flight Center.

"We wanted to go a step beyond just testing an injector and demonstrate how 3-D printing could revolutionize rocket designs for increased system performance," said Chris Singer, director of Marshall's Engineering Directorate. "The parts performed exceptionally well during the tests."

NASA engineers pushed the limits of technology by designing a rocket engine injector -- a highly complex part that sends propellant into the engine -- with design features that took advantage of 3-D printing. To make the parts, the design was entered into the 3-D printer's

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World's Largest Spacecraft Welding Tool for Space Launch System Complete; Follow Events Live on Marshall's ExplorNet

By Shannon Ridinger

Building a rocket with a core stage that towers more than 200 feet tall with a diameter of 27.6 feet is no easy feat. At NASA's Michoud Assembly Facility, manufacturing for NASA's Space Launch System, America's next heavy-lift rocket, is in full swing. This week, the program will celebrate a major milestone with the completion of the Vertical Assembly Center (VAC).

The VAC is the final of six major tools that will weld together the rocket's core stage and ultimately allow SLS to launch astronauts aboard the Orion Multi-Purpose Crew Vehicle farther into the solar system than ever before. Standing at 170 feet tall, it is among the

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computer. The printer then built each part by layering metal powder and fusing it together with a laser, a process known as selective laser melting.

The additive manufacturing process allowed rocket designers to create an injector with 40 individual spray elements, all printed as a single component rather than manufactured individually. The part was similar in size to injectors that power small rocket engines and similar in design to injectors for large engines, such as the RS-25 engine that will power NASA's Space Launch System rocket, the heavy-lift, exploration-class rocket under development to take humans beyond Earth orbit and to Mars.

"The entire injector had only two parts," said Brad Bullard, a propulsion engineer at the Marshall Center. "If we had made it the old-fashioned way, 163 parts would have had to be built and then assembled together. This process saves us time and money and allows us to build a part that will enhance rocket engine performance and be less prone to failure."

Two rocket injectors were tested for five seconds each, producing 20,000 pounds of thrust. Designers created complex geometric flow patterns that allowed oxygen and hydrogen to swirl together before combusting at 1,400 pounds per square inch and temperatures up to 6,000 degrees Fahrenheit. NASA engineers used this opportunity to work with two separate companies -- Solid Concepts in Valencia, California; and Directed Manufacturing in Austin, Texas. Each company printed one injector.

"One of our goals is to collaborate with a variety of companies and establish standards for this new manufacturing process," explained Jason Turpin, a Marshall propulsion engineer. "We are working with industry to learn how to take advantage of additive manufacturing in every stage of space hardware construction from design to operations in space. We are applying everything we learn about making rocket engine components to the Space Launch System and other space hardware."

Additive manufacturing not only helped engineers build and test a rocket injector with a unique design, but it also enabled them to test faster and smarter. Using Marshall's in-house capability to design and produce small 3-D printed parts quickly, the propulsion and materials laboratories can work together to apply quick modifications to the test stand or the rocket component.

Randall McAllister, a Marshall propulsion technician, installs a complex rocket engine injector made using additive manufacturing or 3-D printing. The tests were performed on Test Stand 116 at the Marshall Center. Testing of various rocket components, such as valves, injectors, and nozzles will improve the design of the future Space Launch System and other spacecraft engines. (NASA/MSFC/ Emmett Given)

"Having an in-house additive manufacturing capability allows us to look at test data, modify parts or the test stand based on the data, implement changes quickly and get back to testing," said Nicholas Case, a propulsion engineer leading the testing. "This speeds up the whole design, development and testing process and allows us to try innovative designs with less risk and cost to projects."

Marshall engineers have tested increasingly complex injectors, rocket nozzles and other components with the goal of reducing the manufacturing complexity and the time and cost of building and assembling future engines. Additive manufacturing is a key technology for enhancing rocket designs and enabling missions into deep space.

Watch this video to see the most complext 3-D printed rocket injector ever built by NASA roar to life on the test stand at Marshall.

'Space 2100' Teams Reap Benefits Today While Considering Marshall's Tomorrow

By Kenneth Kesner

There is a program at NASA's Marshall Space Flight Center in which participants get to actually do what some people think everyone in NASA does all the time: Think about the future.

The program is called "Space 2100." It was proposed by Center Director Patrick Scheuermann as a way to encourage employees from a variety of offices and levels to get involved in thinking creatively about the work of Marshall and NASA in the next century.

To participate, employees are usually nominated by supervisors or managers, but it is open to others, said Alayna Devineni, a coordinator of Space 2100 and a strategic integrator in the Center Strategic Development and Integration Office, part of the Office of Strategic Analysis & Communications. Two small groups or teams then meet a couple of times a week for about a month in a Space 2100 "sprint." They later present their results to Marshall leadership and other groups.

The first sprint, in 2013, answered three basic questions: What will the world look like in 2100? What grand challenges will the world face? How will NASA and Marshall fit in?

The recently completed second Space 2100 sprint worked slightly differently, Devineni said. Some participants formed a "Phase One" team that developed a scenario involving activities that might be taking place in cis-lunar space in the year 2050. Then, "Phase Two" teams built on those ideas and information, filling in details about the technological, cultural, economic and other dynamics that could influence or create the "2050 Cis-Lunar Econosphere."

With so much critical work day-to-day, supervisors may be curious why time should be spent today thinking seriously about a tomorrow that's so far off.

"You can say 2050 is more than 30 years in the future, but decisions you make today start to impact what happens 30 years from now," said Mark Nall, manager for technical administrative support of the joint Propulsion Committee at the National

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largest and most complex friction-stir-welding systems ever built, and took over 1,000 tons of steel to construct. The core stage elements that will be welded in the VAC store cryogenic liquid hydrogen and liquid oxygen that will feed the rocket's four RS-25 engines.

This week, NASA's Marshall Space Flight Center has highlighted many of the Michoud and SLS accomplishments with employee interviews, videos, photos and articles on the ExplorNet homepage and will continue this coverage all week. On Sept. 12, there will be a ribbon-cutting ceremony at Michoud marking the VAC completion.

Employees are encouraged to join the "live coverage" of the ribbon cutting on ExplorNet with real-time posts of videos, pictures and commentary that will be posted throughout the day. NASA Administrator Charlie Bolden; Marshall Center Director Patrick Scheuermann; Michoud Assembly Facility Director Roy Malone; SLS Program Manager Todd May; NASA astronaut Patrick Forrester; and Boeing Vice President and SLS Program Manager Virginia Barnes will be on hand to give remarks and to cut the ribbon. The ribbon-cutting ceremony will air live on NASA TV and the agency's website at 10 a.m.

Employees and the public can also follow the VAC events via the Marshall and SLS Twitter accounts, @NASA_Marshall and @NASA_SLS, using the hashtag #weldingwonder.

Ridinger is a public affairs officer in the Office of Strategic Analysis & Communications.

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Institute of Rocket Propulsion Systems. He was involved in both Space 2100 sprints held to date.

"Even if we don't see the suggestions we make implemented, it gives us something to think about as we progress," said Kristin Pollard Kiel, an attorney in Marshall's Office of Chief Counsel who participated in the second sprint. In a way, she said, the exercise provides a sense of ownership in the future of the center.

A major benefit of the Space 2100 experience is the chance to meet and work with people at the center whose paths don't usually cross, said Drew Smith, assistant manager of the Workforce Strategy and Planning Office in the Office of Human Capital. Participants from a variety of fields must find common language to explain their ideas, which promotes fresh thinking and great networking.

"That's probably one of my biggest 'take-aways' from the experience," Smith said. "Without Space 2100 I would probably have never known these people. You can't lose. And I left every meeting even more excited about Marshall's future."

For more information about Space 2100 and future sprints, contact Alayna Devineni.

Kesner, an ASRC Federal/Analytical Services employee, supports the Office of Strategic Analysis & Communications.

Space 2100 is Focus of Innovation & Technology Information Exchange

The "Space 2100" program at NASA's Marshall Space Flight Center will be the topic of September's Innovation and Technology Information Exchange, or I&TIE, from 1-2:30 p.m. Sept. 16, in Morris Auditorium, Building 4200.

Marshall Associate Director Robin Henderson will open the meeting, during which members of the latest Space 2100 "sprint" will talk about their experience and some of the details of their work envisioning a "2050 Cis-Lunar Econosphere." Larry Leopard, director of Marshall's Space Systems Department, will discuss the benefits of both individual and organizational innovation, and how it can be developed to achieve the center's goals and vision.

All Marshall team members are invited to submit his or her own ideas about "What will the world look like in 2100?" and "What will we be doing in space in 2100?" online at the Innovation & Technology ExplorNet page. Employees submitting the top three ideas as voted on by the workforce will receive awards at the Sept. 16 I&TIE event. Ideas can also be brought for discussion during the event.

I&TIE events are organized by the Office of the Chief Technologist. Find more information here.

City of Cullman Honors NASA

Officials from Cullman, Alabama, visited NASA's Marshall Space Flight Center on Sept. 3 to present a proclamation designating the week of Sept. 15-20 as "NASA Week in Cullman." From left are Christopher Smith, Cullman High School band director; Mary Hovater, of Marshall's Office of Strategic Analysis & Communications; Cullman Police Chief Kenny Culpepper; Marshall Center Director Patrick Scheuermann; and Cullman Mayor Max Townson. (NASA/MSFC/Emmett Given)

Lace 'Em Up: Registration Opens for 2014 Racin' the Station Duathlon

By Bill Hubscher

The International Space Station travels approximately 17,000 mph, which means it can make one orbit of Earth in just over 90 minutes.

You don't have to move as fast as the orbiting laboratory, but the Marshall Space Flight Center is inviting athletes of all ages and styles, from couch potato to weekend warrior, to race the space station by finishing a specially designed course in the same amount of time it takes for the station to finish one circuit around the planet.

Registration is open for the third annual Racin' the Station duathlon at the Marshall Center on Sept. 27. Participants can continue to register online for the event up until a few days before the race.

"It started as a scholarship fundraiser for the Marshall Association," said race founder and director Kent Criswell, a team lead in Marshall's Facilities Planning Office. "We wanted to tie in a space theme and, based on the average time to run this specific duathlon course compared to the orbit of the station, it was the perfect fit! The event has grown the past couple of years and we're hoping for a record turnout this year."

The timed course for adults begins at 8:30 a.m. with a 3.14 km run, followed by a 23 km bicycle ride, and finishes with another 3.14 km run, with the start and finish line at the Marshall's Wellness Center Building 4315. The length of the running portion of the race is not a coincidence. Criswell and race organizers arranged the distance to coincide with the number pi or π approximately equal to 3.14159. If the entire race seems too vigorous, adult participants can form two-person relay teams where one does the running portions and a partner handles the cycling.

Athletes begin the first running section of the 2013 Racin' the Station duathlon outside of the Wellness Center at Marshall. (NASA/MSFC/Fred Deaton)

One of the younger athletes receives encouragement while tackling the "anti-duathlon" at the 2013 Racin' the Station duathlon at the Marshall Center. (NASA/MSFC/Emmett Given)

After a successful inaugural race in 2012, Criswell introduced a youth "anti-duathlon" in 2013 where participants bike, run and bike again on a selection of shorter courses -- also based on pi -- that begin immediately following the main event. There are two different overall lengths based on the self-assessed ability of the youth. The short course starts and finishes with a two-mile bike ride (approximately 3.14 km) with a half-mile run in between. The youth long course is twice the size of the short: four-mile rides with a one-mile run separating them.

Racers will travel by many of Marshall's facilities including the Payload Operations Integration Center, the command post of space station science. At race headquarters, they will have the opportunity to learn about NASA programs, including the International Space Station, the Space Launch System, the United Launch Alliance Atlas IV and Delta V rockets and exhibits of the Patriot missile and Unmanned Aerial Vehicles from the U.S. Army.

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International Observe the Moon Night Draws Astronomers of All Ages

Caroline Springfield gets an up-close look at the lunar surface from one of the many high-powered telescopes on-hand Sept. 6 at Marshall's International Observe the Moon Night event at NASA's Education Training Facility, located next to the U.S. Space & Rocket Center. The event, sponsored by Marshall's Discovery and New Frontiers Program, is designed to encourage educators and moon enthusiasts around the globe to gather together to learn more about Earth's moon. (NASA/MSFC/Emmett Given)

Racin' the Station

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"Many people who want to race don't have access to Redstone Arsenal or know what we do at Marshall," said Criswell. "This event provides a unique opportunity for them to learn about all of Team Redstone's work here while participating in a healthy activity and getting to meet some of the engineers and scientists who work on America's space program."

Because the race is held on Redstone, a federal installation, participation is restricted to U.S. citizens. Prizes will be awarded in multiple categories. For details on the race, including course maps, distances, requirements to access Redstone and to register, email ISSduathlon@gmail.com and visit the Racin' the Station Duathalon website.

Hubscher, an ASRC Federal/Analytical Services employee, supports the Office of Strategic Analysis & Communications.