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Destination: Deep space

NASA Deputy Administrator Dava Newman stands with Stennis Director Rick Gilbrech during an RS-25 engine test on the A-1 Test Stand on Aug. 13. The 535-second test marked another step toward NASA's return to deep-space missions. Four RS-25 engines, all to be tested at Stennis will power the core stage of NASA's new Space Launch System, which is being developed to carry humans deeper into space than ever before, to such destinations as an asteroid and Mars. For more on Newman's daylong visit to Stennis, see pages 7-8.

Galloway named deputy director for Stennis Space Center

See page 15

"Our guests from all over the world depended on us to create a memorable test firing experience for them. We did not disappoint."

From the desk of

Pamela Covington

Manager, Office of Communications, Stennis Space Center

NASA Aministrator Charlie Bolden was recently quoted as saying, "Our nation and citizens all over the world are depending on us to lead in this grand and exciting adventure known as space exploration, and we will not disappoint." I felt a similar sense of commitment as I prepared my team in the Office of Communications to welcome over 1,200 guests to our center for a major milestone RS-25 test firing on Aug. 13.

Stennis is playing a critical role on the front end of the future of space exploration. Our engineers have been testing an RS-25 developmental engine since earlier this year, and work is underway on the B-2 Test Stand to prepare for a hot fire of the Space Launch System core stage with four RS-25 engines. Stennis has a long testing history with the world's most reliable engines, which propelled the space shuttle for three decades. On Aug. 13, we had a chance to showcase what we do best – test powerful rocket engines.

The week leading up to the test firing was a busy and exciting time. Each office had a contributing role in planning and executing. A sense of pride and esprit de corps bubbled up in the workforce as the test date approached. We capitalized on the momentum with a week of "show your spirit" activities. The neon shirts and crazy sock days were just the right remedies to ease stress levels as the team worked long hours for the big day.

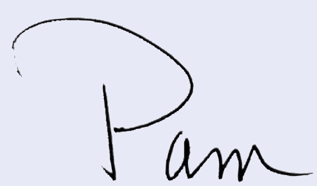
The NASA deputy administrator paid her inaugural visit to the center on test day. It was a great opportunity to introduce her to Stennis and to have her speak to the workforce before the big test. Dr. Dava Newman got the troops rallied when she said, "All roads to space lead through Stennis in Mississippi. ... Everything has to come here to get us started."

Test day had a similar feel to the old Space Shuttle Guest Operations days. NASA teammates from across the agency, astronauts, contractor families, and commercial partners connected, smiling, greeting each other in anticipation of the countdown.

At one minute to the scheduled 4 p.m. test time, it happened. The guests stood still as the shake, rattle and roar of 512,000 pounds of thrust from a 7,775-pound engine, operating at temperatures ranging from minus 423 degrees Fahrenheit to 6,000 degrees Fahrenheit, filled the air. It is the greatest fire-and-water show on earth. It was amazing!

Our guests from all over the world depended on us to create a memorable test firing experience for them. We did not disappoint.

It was a great day for Stennis.



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FULFILLING NASA'S EXPLORATION MISSION

Countdown to deep space continues with Aug. 13 RS-25 test

NASA's countdown to deep space continued Aug. 13 with a 535-second test of its Space Launch System (SLS) RS-25 rocket engine to collect engine performance data at NASA's Stennis Space Center. SLS will launch astronauts in the Orion spacecraft on missions to deep space and eventually on the journey to Mars. Operators on the A-1 Test Stand at Stennis are conducting the test series to qualify an all-new engine controller and put the upgraded former space shuttle main engines through the rigorous temperature and pressure conditions they will experience during a SLS mission.

One final test of this RS-25 developmental engine is planned in this series; testing of flight engines begins later this fall.

More than 1,200 people, including elected officials and community leaders, media and social media representatives, and NASA and contractor employees and family members viewed the test. Guests saw Stennis facilities and test stands, the Aerojet Rocketdyne engine assembly facility, and the Pegasus barge that will transport the SLS core stage from NASA's Michoud Assembly Facility in New Orleans to Stennis for testing then to Kennedy Space Center in Florida for launch.

An initial 70-metric-ton (77-ton) SLS configuration will use four RS-25 engines for the core stage, along with two five-segment solid rocket boosters, providing more lift to orbit than any current launch vehicle. The core stage for the first SLS and Orion integrated flight– Exploration Mission-1 – also will be tested at Stennis. That test will involve simultaneous firing of the four RS-25 engines just as during an actual launch.

The RS-25 engine gives SLS a proven, high performance, affordable main propulsion system for deep space exploration. It is one of the most experienced large rocket engines in the world, with more than a million seconds of ground test and flight operations time. Aerojet Rocketdyne of Sacramento, California, is the prime contractor for the RS-25 engine work. NASA's Marshall Space Flight Center in Huntsville, Ala., manages the SLS Program.

FULFILLING NASA'S EXPLORATION MISSION

Stennis hosts full day of activities for RS-25 engine test

It was a full day of activity for Stennis employees, family members and special guests who gathered onsite to view the RS-25 engine test on Aug. 13. Onlookers included NASA officials, NASA Space Flight Awareness Honorees, a variety of invited guests, traditional and social media members, as well as Stennis employees and their families. More than 1,200 visitors viewed the test from opposite angles, culminating a day that featured opportunities to visit with astronauts and enjoy family fun.

FULFILLING NASA'S EXPLORATION MISSION

Deputy administrator Newman spends busy day at Stennis

NASA Deputy Administrator Dava Newman enjoyed a full day of activities during a visit to Stennis Space Center on Aug. 13. In addition to viewing an RS-25 engine test (see page 1), Newman toured Stennis facilities, visited with traditional and social media representatives (top left photo), met with Stennis leaders (bottom left photo), held an all hands session with Stennis employees (bottom center photo) and toured the B-2 Test Stand for a briefing on preparations to test the core stage of NASA's new Space Launch System vehicle (top right photo). Following the engine test, Newman congratulated operators in the A Test Complex Control Center (bottom right photo). The visit was Newman's first to Stennis since she joined NASA as deputy administrator in May.

'Top of the world' – NASA tops out B-2 Test Stand structural framework

NASA moved 100 feet closer to its return to deep-space missions early this month, celebrating the "topping out" of structural steel work on the Main Propulsion Test Article (MPTA) frame on the B-2 Test Stand at Stennis Space Center.

The distance may not sound like much, but completion of the steel work marks a major milestone as NASA prepares to test the core stage of its new Space Launch System (SLS), being developed to carry humans deeper into space than ever before.

"Every step brings us closer and closer to a new era of space exploration," Stennis Director Rick Gilbrech said. "These are exciting days, and it is critical for Stennis to fulfill our test role on the frontlines. As has been said time and again, the return to deep space goes right through Stennis and south Mississippi."

With the addition of about 1 million pounds of structural steel rising some 100 feet, the new MPTA framework alters the Stennis skyline and moves NASA ever-so-closer to the day when a SLS flight core stage is installed on the stand for testing.

Stage testing is not new to Stennis or the B-2 stand. The structure was built in the 1960s to test Saturn V stages that carried humans to the moon. From 1977 to 1981, it also was used to test the space shuttle propulsion system, which involved installing an external tank, simulated shuttle orbiter and three main engines on the stand. The engines then were fired simultaneously to ensure the propulsion system would perform as needed. It was a critical series of tests, considering the shuttle flew to space for the first time with a two-person crew; there were no uncrewed test flights of the system.

The SLS core stage testing will be just as important since it is being conducted on the actual stage that will fly on the first SLS mission. For the testing, the vehicle's core stage, with four RS-25 engines, will be installed on the stand. All four engines will be fired simultaneously, just as during an actual launch.

NASA has been renovating the B-2 Test Stand for more than two years in preparation for the SLS test series. Months of studies and evaluations preceded the start of physical work on the stand.

The project is divided into three stages: restoration, buildout and installation of special test equipment. The first phase involves restoring the stand to its original design condition, which can be adapted to test any number of stages. The second phase focuses on structural renovations needed to accommodate the SLS core stage specifically. The final phase is installation of all the various interfaces needed to test the stage.

(Above photo) This 2003 image shows the B-1/B-2 Test Stand as it looked before NASA began renovation work to prepare for Space Launch System stage testing.

(Right photo) A recent image shows the new profile of the B-1/B-2 Test Stand. The white framework structure on the right is needed to accommodate the large Space Launch System core stage, which will be tested at Stennis prior to a scheduled 2018 flight.

Overall, no area of the stand is going untouched, including structural, mechanical, electrical and piping. For instance, one major component was installation of an upgraded high-pressure industrial water system to deliver the added flow volume needed to support the core stage testing.

A major focus also has been the MPTA framework on the stand. The existing configuration was too small to accommodate the larger SLS core stage, which is 27.6 feet in diameter and will stand more than 200 feet tall when installed.

Preparing for the new rocket stage required repositioning the original MPTA framework – all 1.2 million pounds worth – 20 feet atop the test stand base platform, a move that was completed in August 2014. Another 1 million pounds of fabricated steel then was added to extend the framework from 61 feet high to about 160 feet high.

NASA celebrated completion of the structural steel work. "It is another step but a big one that adds to the excitement," said Barry Robinson, SLS core stage project manager at Stennis. "Any time you start a project from the ground up, it's hard to visualize. With this step completed, it is not hard to visualize at all."

Even as the milestone is celebrated, work continues on several fronts. The first uncrewed flight of the SLS is set for 2018, and it will be powered at launch by the core stage tested at Stennis. That leaves little time for schedule deviation, despite inevitable issues that arise. Robinson said everyone involved in the effort is diligent and focused.

"Everything matters: every nut, every bolt, every weld, every piece of pipe, every concrete pour," he said. "Everything. We have a good team that understands we have to be diligent. There can be no shortcuts. We can't afford them. This is our future."

FULFILLING NASA'S EXPLORATION MISSION

History in the making: Dealing with explosive engine exhaust

Editor's Note: The following is the fourth in a series of articles highlighting the A-1 Test Stand at Stennis Space Center. The articles focus on aspects of the stand and how they enable rocket engine testing that supports America's human space program. The series is presented as NASA engineers test RS-25 engines on the A-1 stand. The engines will power the core stage of NASA's new Space Launch System, which is being built to carry humans deeper into space than ever before.

An engineer will tell you dealing with the exhaust from a rocket engine test is one of the simpler test-related issues to address. To the non-engineer, however, dealing with an explosive snake of fire exiting an engine at temperatures hot enough to melt steel does not, in any way, equate with simple.

Rocket engines are tested just as they are fired during an actual launch, so the ribbon of fire behind an ascending rocket is the same as the one exiting the engine during a test. Fortunately, the stand includes a simple process for channeling that flame.

"It's the same approach that has been used since the stand was built in the 1960s," explained Jeff Henderson, A-1 Test Stand director. "All we've done since then is replace some valves and such with newer designs. As far as concept, it works like it always has."

The approach may be simple, but considering its implementation can be mind-boggling.

For one thing, there is the temperature of the exhaust, as high as 6,000 degrees Fahrenheit. That is hot enough to melt most known materials, including diamonds, as well as the flame deflector itself.

To keep that from happening, operators spray water to cool the deflector – lots of water. The deflector has a network of 21 water cells, divided into four groups. Each group is serviced by a 24-inch water valve and individually pressurized.

Before, during and after a test, water is sprayed through thousands of small holes drilled in a designed pattern in the deflector. Different engines fire differently, which means exhaust may hit one area of the deflector more than another. Also, gimbaling an engine during a test redirects thrust into the deflector. Gimbaling involves rotating the engine within a 10-degree circular range, as is needed during an actual flight to direct thrust and maintain proper trajectory. If needed, holes in the deflector could be reconfigured to direct the spray of water onto "hot spots."

During an RS-25 engine test, 170,000 gallons of water flows to the A-1 Test Stand every minute, all of it directed to the flame deflector for cooling. During a 535-second test, just shy of nine minutes, that translates to more than 1.5 million gallons of water flowing into the deflector – and that total does not include the pre- and post-test usage.

Exhaust exiting an RS-25 rocket engine during a test can reach temperatures as high as 6,000 degrees, hot enough to melt most materials, including the test stand flame deflector, if left unprotected.

"An engine test takes a huge amount of water flow," Henderson noted.

It is supplied by the High-Pressure Water Facility at Stennis. For tests on the A-1 stand, water is pumped from the nearby 66-million-gallon reservoir through 75-inch lines to the test stand. Installed four decades ago, the entire test complex water piping system is now being upgraded.

If the scope of those numbers are not daunting enough, consider the energy and volume of exhaust created by an engine test. Propellants enter an engine in ultra-cold, low-energy states. With mixing and combustion, they explode into ultra-hot, high-energy gases. As much of that energy as possible is harnessed to create the thrust that lifts a rocket into the sky.

Think of a garden hose, or a high-pressure fire hose. Left open-ended, a certain amount of water will flow through the line. Put a nozzle on the end and narrow the opening and the pressure builds in the line as the water is channeled through the nozzle. The building pressure affects the hose, which recoils with harnessed energy. This is especially evident in fire hoses, which require considerable force to hold in place. In a rocket engine, directing the exploding propellants through the nozzle creates the same recoiling pressure. It is called thrust.

As for the water exiting the hose, it is largely escaping energy. The same is true for engine exhaust; it represents the unharnessed energy. During an engine test, this energy is directed down and out of the stand by the L-shaped deflector. Combined with the incoming water flow, the hot gaseous vapor converts to steam and creates the billowing white cloud that exits the test stand.

Henderson said many observers are surprised to learn the cloud is steam instead of smoke. Indeed, if wind and atmospheric conditions are right, it can drift over onlookers and pelt them with raindrops.

The water that does not convert to steam is carried out of the deflector through a small concrete spillway into the adjacent field. It leaves the stand tremendously cooled; a measurement taken near the deflector registered exiting water at only 106 degrees.

The deflector is monitored during tests and inspected afterwards to ensure no leaks are occurring. Inspections also examine how the deflector is heating; quite a bit of thermal analysis has been conducted on the deflector through the years as well. At times, Henderson even has paint applied to the steel component so he can check post-test to see how various areas are heating. Identified patterns may dictate a change in water spray pattern.

The anchoring for the deflector is inspected as well, since it is not a rigid system. It has to be able to move during a test to handle the force of the exhaust and the water, as well as to expand and contract as it heats and cools. "It's meant to move," Henderson said. "It's not designed the way it is for no reason. You look at it, and you really do have a lot going on there."

The A-1 Test Stand flame deflector, with the help of tens of thousands of gallons of pressurized water, plays a simple, yet important role in RS-25 rocket engine testing, directing ultra-hot exhaust safely out of the structure.

FULFILLING NASA'S EXPLORATION MISSION

High-pressure gas facility provides unnoticed but critical support for Stennis

People touring NASA's Stennis Space Center are excited to view the large stands that tested rocket engines used to carry humans to the moon and to power 30 years of space shuttle missions. The same stands are testing engines for the next great era of American space exploration.

They inevitably fail to notice the small white high-pressure gas facility (HPGF) they pass on the way to the stands. Its white building, storage tanks and storage spheres get bare, if any, mention by tour guides.

However, without the work of that facility, commonly referred to as "the gashouse," every one of the large test stands would be useless. "It's the starting block of the test area," explained Haynes Haselmaier, a Mississippi Research Consortium employee who serves as the sustaining engineer for valves, pumps and compressors at Stennis. "It is an amazingly versatile facility and operates 24/7. Without it, we're dead in the water."

It only takes a few minutes of conversation to understand why.

The HPGF is responsible for providing the gaseous nitrogen, helium and hydrogen, as well as the missile grade air, needed to support test operations, for pressurization and purging propellant lines and systems, for valve operation and to push propellant to barges and test stands. It includes a network of miles and miles of pipe and has a very simple objective: do whatever it takes to maintain test systems and support test activity.

It has never failed in that task.

Rocket test systems are not like lawnmowers, which can be used on a weekend and shut off and stored until needed again. Rocket test systems, in turn, must maintain constant pressures to support propellant storage and ongoing flows to ensure system integrity and purity. "It's an unnoticed, inglorious thing, but it's essential," Haselmaier said. "The record they have is remarkable."

In fact, the facility began operation in the 1960s and has never faltered, adding up to more than 40 years of continuous service. Gas of one form or another is constantly flowing through the miles-long network that stretches to the test stands and other areas of Stennis to ensure all is maintained in order.

The task is accomplished thanks to a small crew of operators, who work two shifts and represent at least 100 years of experience. "This is a unique group," said Billy Davis, a Lockheed Martin employee who serves as cryogenic supervisor for the HPGF crew. "They represent a lot of knowledge and expertise, and they are very committed. They get called all times of the day and night as needs arise."

(Right photo) A 2015 aerial photo shows the high-pressure gas facility at Stennis Space Center. Though small and largely unnoticed by visitors, the facility provides critical support for rocket engine testing and other activities at the NASA site. The facility has provided continuous service to the site for more than 40 years.

(Left photo) Several members of the high-pressure gas facility stand in front of some of the spheres and tanks used to store and distribute gaseous nitrogen, helium and hydrogen, as well as missile-grade air, throughout Stennis. Shown are (l to r): Supervisor Billy Davis, James Cain, Lavell Ladner, Craig Shaw, Jerry Duggan and Jason Saucier.

Though small, the HPGF crew and facilities maintain a diverse operation. Helium is received in gaseous form, but hydrogen and nitrogen arrive in liquid form, are pumped to high pressure, then are vaporized and distributed through the piping network. Air is collected from the atmosphere, then scrubbed and cleaned through facility compressors to reach the missile-grade purity needed.

"The purity of gases that have to be delivered is very high," Haselmaier said. "Depressurization of the facility system could contaminate countless pipes, valves and components. Recovery from such an event could take months and cost millions of dollars."

The HPGF deals not only in quality but quantity as well. In 2014, the facility received 68,000 pounds of liquid hydrogen, 10.4 million standard cubic feet of helium and more than 24,000 tons of liquid nitrogen. Depending on the frequency of testing in prior years, those numbers have ranged two to three times higher.

The numbers grow even more impressive when one considers that some of the equipment being used is original, dating back more than 40 years. However, Stennis has successfully upgraded much of the equipment. Pumps, compressors and other important equipment have been replaced with newer, more efficient models, with a focus on automating processes when possible. The work is no small undertaking. The facility cannot be shut down for stretches of time; it must maintain continuous operation. Maintenance and repair/replacement work must be coordinated to prevent any loss of service.

The nitrogen system is largely automated now, and work is under way to automate other areas as well. Haselmaier said that as a result of upgrades, maintenance costs are down by more than 80 percent for the nitrogen system, while capacity has increased significantly.

Most of the replacement work has occurred since Hurricane Katrina gave the facility a real test in 2005. Following the storm, commercial power was lost. The large generators at the high-pressure water facility had to supply power to HPGF. Since then, the facility has acquired a large diesel generator of its own to serve as backup.

In addition, delivery of elements were an issue during the storm's aftermath, when roads were blocked and supply chains severely hampered. Fortunately, some reserve is built into the system, and enough deliveries were made to ensure propellant systems were not compromised. Thus, as has been the case with the high-pressure gas facility for more than 40 years and counting, there was no loss of service.

FULFILLING NASA'S EXPLORATION MISSION

Galloway named Stennis deputy director

NASA announced Aug. 10 that Randy Galloway has been named Deputy Director of Stennis Space Center. He has extensive geographic mobility across NASA, having served at several other centers in key leadership roles.

"Randy demonstrates the leadership and managerial skills found in senior level executives to ensure technical excellence and alignment with the agency's vision," Stennis Space Center Director Richard Gilbrech said.

In his previous position, Galloway served as director of the Engineering and Test Directorate at Stennis since 2007, where he has had responsibility for executing the center's major lines of business in propulsion test management and execution, space technology and applied sciences. He has an extensive background and experience in the propulsion test world.

Galloway succeeds Jerry Cook, who will return to the Marshall Space Flight Center, Huntsville, Alabama, where he will serve as the Exploration Systems Development chief engineer and director of Cross-Program Systems Integration.

"Jerry is extremely motivated and has been a positive influence in helping keep the workforce at Stennis motivated through his diversity and inclusion efforts, as well as in accomplishing the center's mission and achieving results," said Gilbrech.

Galloway's successor as director of the Stennis Engineering and Test Directorate is John Bailey, who has been serving as deputy director for the directorate.

Pedal to the metal: RS-25 engine revs up again for test No. 5

In auto racing parlance, NASA engineers put the "pedal to the metal" during a July 17 test of its Space Launch System (SLS) RS-25 rocket engine at Stennis Space Center. During a 535-second test, operators ran the RS-25 through a series of power levels, including a period of firing at 109 percent of the engine's rated power. Data collected on performance of the engine at the various power levels will aid in adapting the former space shuttle engines to the new SLS vehicle mission requirements, including development of an all-new engine controller and software. Four RS-25 engines will use the added performance to help power the SLS core stage during launch. The SLS is being developed to carry humans deeper into space than ever before, to such destinations as an asteroid and Mars. When fully developed, the heavy-lift version of the spacecraft will be the largest, most powerful rocket ever built. Prior to the first launch – Exploration Mission-1, the SLS first stage will be tested on the B-2 Test Stand at Stennis, which will involve simultaneously firing its four RS-25 engines just as during a launch. Modifications are continuing to prepare the B-2 stand for the test series.

NASA honors Stennis employees

Several employees from Stennis Space Center and other NASA centers were recognized for contributions to flight safety with NASA Space Flight Awareness (SFA) awards during an Aug. 12 ceremony in New Orleans. The ceremony was held in conjunction with the Aug. 13 test of an RS-25 engine at Stennis. Awards were presented by NASA Deputy Associate Administrator for Exploration Systems Development Bill Hill, astronaut Jim Kelly and Stennis Associate Director Ken Human. Honorees are listed below with their company designation; unless specified, honorees are from Stennis. Honorees included: (Front row, l to r) Tracey Martin (NASA Shared Services Center – ASTS), Monica Watts (NASA) and Cabrina Bell (NASA). (Middle row, l to r) Robert Manton (A^2Research), David Golden (A^2Research), Fran Songy (Lockheed Martin Test Operations Contract Group), Dale Green (Jacobs Facility Operating Services Contract Group), Peter Berg (Ames Research Center – SGT Inc.) and Jenny Hayes (Glenn Research Center – NASA). (Back row, l to r) Ken Human, Lauren Underwood (NASA), Raymond Keim (Aerojet Rocketdyne), Louis Simmons (Langley Research Center – NASA), Robert Pfister (Defense Contract Management Agency – NASA) and Nick Kiriokos (Armstrong Flight Research Center – NASA). Not pictured are honorees Ronnie Dartez (Lockheed Martin), Stephanie Hamrick (Engineering and Safety Center – NASA) Joey Lizana (Jacobs), Ralph Penton (Aerojet Rocketdyne) and Rodney Valdes (Jacobs).

Stennis hosts Take Our Children to Work Day

Some 200 children of employees at Stennis Space Center resident agencies and organizations visited the rocket engine test site July 23 to participate in annual Take Our Children to Work Day activities. Children enjoyed visiting site facilities and learning about various work performed at the NASA center. Sessions focused on robotics, typhoons, information technology security and other topics.

1960s – Stennis tests Saturn moon rockets

Note: For more than 50 years, NASA's John C. Stennis Space Center has played a pivotal role in the success of the nation's space program. This month's Lagniappe provides a glimpse into the history of the south Mississippi rocket engine test center.

During this time 50 years ago, the Mississippi Test Facility (MTF) was in its final phase of site readiness to static test and prove flight worthy the first and second stages of the Saturn V, a rocket NASA built to send America's astronauts to the moon. President John F. Kennedy's national goal of a manned lunar landing by the end of the '60s decade brought about an early need for a much larger launch vehicle.

The Saturn V (r) shown in comparison with other Saturn rocket vehicles.

After extensive studies were conducted for several months, NASA approved development of an advanced Saturn vehicle, known as Saturn V, on Jan. 25, 1962. The Saturn V, one of three types of Saturn rockets NASA built, was developed under the direction of NASA's Marshall Space Flight Center in Huntsville, Alabama. The two smaller rockets, the Saturn I and Saturn IB, were used to launch humans into Earth orbit. The Saturn V sent them beyond Earth orbit to the moon.

The giant Saturn V Apollo moon rocket, also known as a heavy-lift vehicle, was very powerful. It stood 363 feet tall (about the height of a 36-story building) and 60 feet taller than the Statue of Liberty. When fully fueled for liftoff, the Saturn V weighed 6.2 million pounds, the weight of about 400 elephants. The rocket generated 7.6 million pounds of thrust at launch, creating more power than 85 Hoover Dams. A car that gets 30 miles to a gallon could drive around the world 800 times with the amount of fuel the Saturn V used for a lunar landing mission. It could launch about 130 tons into Earth orbit, which is equivalent to the weight of 10 school buses. It could launch the equivalent of four school buses (50 tons) to the moon.

Of Saturn V's three stages, two of them – the S-1C, also called the booster, and the S-II, the second stage – were tested at MTF. The booster was 138 feet in length and 33 feet in diameter. The propulsion system used five F-1 engines for a total stage thrust of 7,500,000 pounds. The F-1 was developed for NASA by the Rocketdyne Division of North American Aviation, and the design of the stage was a joint project of Marshall and the Boeing Co., which was selected to produce flight units at NASA Michoud Operations in New Orleans. Most of the flight units were static tested at MTF. The S-II, developed by the Space and Information Systems Division of North American Aviation Inc., was 82 feet long and 33 feet in diameter. The propulsion system used five Rocketdyne-developed J-2 engines, which produced a total of 1,000,000 pounds of thrust.

In 1968, the Saturn V took the first astronauts – Apollo 8's Frank Borman, Jim Lovell and Bill Anders – to the moon, circling it 10 times on Christmas Eve. Seven months later, Apollo 11 astronauts Neil Armstrong and Edwin E. Aldrin Jr. were the first to land on the moon as fellow astronaut Michael Collins orbited above in the command module. Astronauts landed on the moon five more times, and the last Saturn V was launched in 1973 without a crew. It launched the Skylab space station into orbit around Earth.

For more information about Apollo's Saturn launch vehicles, read Stages to Saturn by Roger E. Bilstein.

Office of Diversity and Equal Opportunity

Religion discrimination and accommodation

The following information was gathered from the U.S. Department of Labor. It is Part 1 of 2.

Title VII of the Civil Rights Act of 1964 prohibits federal agencies from discriminating against employees or applicants because of their religious beliefs in hiring, firing and other terms and conditions of employment. Additionally, Title VII requires federal agencies to reasonably accommodate the religious beliefs or practices of employees or applicants unless doing so would impose an undue hardship upon the agency.

Religious Discrimination

The Equal Employment Opportunity Commission (EEOC) defines "religious beliefs" to include theistic beliefs (i.e. those that include a belief in God), as well as non-theistic moral or ethical beliefs about right and wrong that are sincerely held with the strength of traditional religious views. In most cases, whether or not a practice or belief is religious is not an issue. Religion typically concerns "ultimate ideas" about "life, purpose and death," while social, political and/or economic philosophies and mere personal preferences are not "religious" beliefs. It is important to consider that an individual's religious beliefs may change over time. Additionally, individuals may choose to adhere to some tenets of their religion but not to others, and/or individuals may have a sincere belief in a religious practice that is not observed by other followers of their religion.

Title VII also protects employees or applicants from discrimination if they do not subscribe to a particular religious view and/or are atheist. Religious discrimination can also involve treating someone differently because that person is married to (or associated with) an individual of a particular religion or because of their connection with a religious organization or group. An employee cannot be forced to participate (or not participate) in a religious activity as a condition of employment.

Religious Accommodation

Title VII requires federal agencies, upon notice of a request, to reasonably accommodate employees whose sincerely held religious beliefs, practices or observances conflict with work requirements, unless the accommodation would create an undue hardship.

What is a religious accommodation? A religious accommodation is any adjustment to the work environment that will allow an employee or applicant to practice their religion. The need for religious accommodation may arise when an individual's religious beliefs, observances or practices conflict with a specific task or requirement of the position or an application process. Accommodation requests often relate to work schedules, dress and grooming, or religious expression in the workplace. If it would not pose an undue hardship, the employer must grant the accommodation.

What is an undue hardship? An agency may justify a refusal to accommodate an individual's religious beliefs or practices if the agency can demonstrate that the accommodation would cause an undue hardship. An accommodation may cause undue hardship if it is costly, compromises workplace safety, decreases workplace efficiency, infringes on the rights of other employees or requires other employees to do more than their share of potentially hazardous or burdensome work. Undue hardship also may be shown if the request for an accommodation violates the terms of a collective bargaining agreement or job rights established through a seniority system. Undue hardship based on cost requires that the agency show more than a de minimis (minimal impact upon the agency's business) cost to the agency. The hardship upon the agency must be genuine and cannot be merely speculative.

The fundamentals of religious accommodation are covered in this first part of a two-part series. Next month's article will discuss how the process of religious accommodation works and protection from harassment or discrimination because of one's religious beliefs.

Hail & Farewell

NASA bids farewell to the following:

Rosalind Baker	Contract Specialist	Office of Procurement
Thally Dao	Summer Intern (Legal)	Office of the Chief Counsel

And welcomes the following:

Christopher Knudsen	AST, Experimental Facility Development	Center Operations Directorate
Robert Simmers	AST, Facility Systems Safety	Safety & Mission Assurance Directorate

Stennis leader hosts summer lunch-and-learn session

Twenty-nine Stennis Space Center faculty fellows and interns participated in a July 20 lunch-and-learn session featuring a presentation by Randy Galloway, then-director of the Stennis Engineering and Test Directorate and since named as Stennis deputy director. During the session, Galloway described his career path and shared personal remembrances and experiences of his involvement in building the International Space Station. The space station represents a blueprint for global cooperation and remains the springboard to NASA's next great leap in space exploration, enabling research and technology developments that will benefit human and robotic exploration of destinations beyond low-Earth orbit, including asteroids and Mars. Galloway also fielded questions from participants following his presentation.

NASA in the News

NASA launches Tumblr account

NASA has launched an official Tumblr profile that will give users a regular dose of space in a blog-like format through text, photos, videos and more. Tumblr is a social media platform that allows users to connect and follow other content creators in a collaborative format. People are able to discover, share and create content that expresses their personality, hobbies and interests. The NASA profile will share information, images and video about agency missions. To follow NASA's account, visit: http://nasa.tumblr.com. Along with the new official NASA Tumblr account, astronaut Peggy Whitson will offer a behind-the-scenes look at an astronaut's journey as she trains for a mission to the International Space Station. It takes a NASA village to train an astronaut, and Whitson's Tumblr will highlight the people who make human spaceflight possible.To follow her Tumblr, visit: http://astropeggy.tumblr.com. These NASA profiles will be joined by two mission accounts. The JunoCam Tumblr will showcase Jupiter images from amateur astronomers and public-processed images from JunoCam on board NASA's Juno mission. The Curiosity rover will share engineering, science and selfies from the surface of Mars. To follow on Tumblr, visit: http://nasajunocam.tumblr.com and http://curiositymarsrover.tumblr.com.

NASA unveils Mars online tools

On the three-year anniversary of the Mars landing of NASA's Curiosity rover, NASA has unveiled two new online tools that open the mysterious terrain of the Red Planet to a new generation of explorers, inviting the public to help with its journey to Mars. Mars Trek is a free, web-based application that provides high-quality, detailed visualizations of the planet using real data from 50 years of NASA exploration and allowing astronomers, citizen scientists and students to study the Red Planet's features. Experience Curiosity allows viewers to journey along with the one-ton rover on its Martian expeditions. The program simulates Mars in 3-D based on actual data from Curiosity and NASA's Mars Reconnaissance Orbiter. "At three years old, Curiosity already has had a rich and fascinating life. This new program lets the public experience some of the rover's adventures first-hand," said Jim Erickson, the project manager for the mission at NASA's Jet Propulsion Laboratory. More information about NASA's journey to Mars is available online at: https://www.nasa.gov/topics/journeytomars. For more about Curiosity, visit: http://www.nasa.gov/msl. To download and print a 3-D model of Curiosity, go to: http://nasa3d.arc.nasa.gov/detail/mars-rover-curiosity.

Access all NASA news releases online at: http://go.usa.gov/3f3KW.