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National Aeronautics and
Space Administration

KENNEDY SPACE CENTER'S

SPACEPORT magazine

NASA Robotic Mining Competition

The Future is Here

KSC transforms its workforce and infrastructure for the Journey to Mars

Aeronautics Research | Mars | Technology | Earth Right Now | ISS | Solar System & Beyond

KENNEDY SPACE CENTER'S

SPACEPORT MAGAZINE

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This issue brings the reader inside the gates of Kennedy Space Center to discover the changes the center is making to its workforce, mission and infrastructure to enable the journey to Mars in the coming decades. NASA is currently working on the challenges of how to get to Mars, how to land and, ultimately, how people will live and work once they arrive on the Red Planet. NASA's Robotic Mining Competition is a stepping stone on this path as NASA engineers are able to watch, first-hand, how students from 46 colleges and universities propose to solve the challenge of mining on Mars, while simultaneously inspiring the next generation of engineers and scientists. NASA is paving the way to Mars; please continue reading to join us on the journey.

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Editor..... Frank Ochoa-Gonzales

Assistant Editor..... Linda Herridge

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Writers Group

Anna Heiney, Bob Granath, Kay Grinter, Linda Herridge, Frank Ochoa-Gonzales, Steven Siceloff

Graphics Group

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

NASA'S LAUNCH SCHEDULE

Date: No Earlier Than June 2, 12:30 p.m. EDT
Mission: Low-Density Supersonic Decelerator (LDSD) Flight Test
Description: NASA's LDSD project is designed to investigate and test breakthrough technologies for landing future robotic and human Mars missions and safely returning large payloads to Earth. The test, performed over the Pacific Ocean, will simulate the supersonic entry and descent speeds at which the spacecraft would be traveling through the Martian atmosphere.
http://go.nasa.gov/1BsoVgf

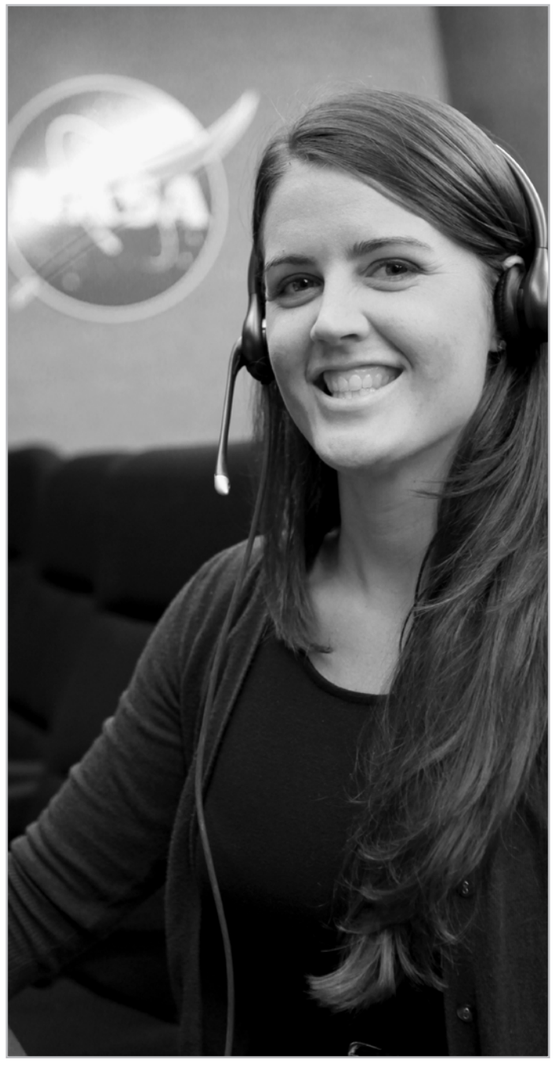
Date: June 26, 11:09 a.m. EDT
Mission: SpaceX CRS-7 Resupply Mission to the International Space Station
Description: Launching from Cape Canaveral Air Force Station, Florida, SpaceX's seventh commercial resupply mission under NASA contract to the International Space Station will deliver several tons of supplies, including new science experiments and technology research.
http://go.nasa.gov/WQkyJf

Date: July
Mission: Progress 60P Cargo Craft
Description: In early July, the Progress 60P resupply vehicle ó- an automated, unpiloted version of the Soyuz spacecraft that is used to bring supplies and fuel ó- launches to ISS.

Date: July
Mission: Expedition 44 Launch to the ISS
Description: In late July, Kjell Lindgren of NASA, Kimiya Yui of JAXA and Oleg Kononenko of Roscosmos launch aboard a Soyuz spacecraft from the Baikonur Cosmodrome, Kazakhstan to the ISS.
http://go.nasa.gov/1BspAy1

I am KENNEDY SPACE CENTER

SAMANTHA FONDER



I am the flight operations engineer for NASA's Launch Services Program (LSP). I work to ensure data from the launch vehicle returns to the customers in real time for all of the unmanned NASA launches. I use the trajectory and sequence of events to understand which antennas around the world can be used to capture data from the rocket while it is in flight. Depending on the results, I may work with other countries or private companies to gain access to their antennas. These antennas may be satellites in space, a dish in the middle of the desert, or a transportable hardware that can be outfitted on a boat or a plane.

I have been in this role for four years, and I still find it very exciting and challenging. Every mission is different, so there always is something new to figure out. My favorite part of my job is interacting with the public. Sometimes it's easy to get caught up in the daily grind, but nearly every time I tell someone outside the gate that I work for NASA, their face lights up and a slew of space questions start to flow. In fact, I usually end up learning a new fun fact about Pluto's moons or the largest asteroid on record. Space has a special way of inspiring people's curiosity, and I feel really fortunate to play a small role in that.

Sami

GETTING THERE

Kennedy director updates path toward spaceport's goals

BY STEVEN SICELOFF

Exploration requires bold initiative and unflinching drive, Kennedy Space Center Director Bob Cabana told an audience at the Florida chapter of the National Space Club recently as he underscored the steps already taken to the convert the center to a multi-user spaceport. Performing the next series of steps correctly is just as critical to establish the nation's premiere launch site on a successful course for the next 50 years, he added.

a presence in low-Earth orbit aboard the International Space Station, but it's time to move on and establish that presence further out into the solar system."

The three programs based at Kennedy are central to meeting the agency's overall mission, Cabana said, and the center's transition to meet the diverse needs of commercial enterprises in aerospace and other research fields is just as critical in making a complete center that serves NASA's

a Kennedy-based effort to involve private industry more deeply than ever before in the development and operation of spacecraft capable of carrying astronauts to the space station. The new spacecraft by Boeing and SpaceX will allow the station crew to grow by one, which is enough to double the scientific time crew members devote to research on the orbiting laboratory.

"Why Mars?" Cabana queried, "It's the one planet in our solar system aside from

"We've established a presence in low-Earth orbit aboard the International Space Station, but it's time to move on and establish that presence further out into the solar system."

BOB CABANA
Director, Kennedy Space Center

More than a mission to firm-up Kennedy's position, Cabana, a former shuttle commander, punctuated the value of a viable center to NASA's goals of meeting the research potential of the International Space Station with research off the Earth for the Earth, proving the Orion and Space Launch System for deep space exploration by astronauts and to the ultimate goal of eventually sending humans on a journey to Mars.

"We want to be pioneers and pioneers leave a safe environment and explore an extreme environment," Cabana said, citing examples ranging from sailors trapped at the South Pole to families that established the communities of the American Midwest to Apollo and the astronauts currently living on the space station. "We've established

needs as well as those of industry.

The Launch Services Program pushes humanity's reach into deep space with launches of the Curiosity rover on Mars and the small fleet of spacecraft orbiting the red planet now. The near future will see more Mars missions with InSight coming up in 2016, along with Osiris-Rex, a spacecraft that will sample an asteroid in a precursor to astronautic exploration missions.

While the robotic missions continue to gather fundamental information about those worlds, astronauts on the station will continue to evaluate measures to cope with long-duration weightlessness and the other aspects of spaceflight a crew would encounter during a Mars trip. Making that work count will depend greatly on the success of the Commercial Crew Program,

Earth that has the most possible resources that can sustain humans. We could actually establish a presence on Mars. It's about learning how to operate away from planet earth for an extended time."

The Space Launch System rocket and Orion spacecraft, which will be served in assembly and at Launch Complex 39B by NASA's Ground Systems Development and Operations Program, are designed to carry astronauts to deep space although Mars is not on the schedule until the 2030s for humans.

"It's not destination-dependent, but the capability we are going to grow will allow us to establish a presence in the solar system beyond planet Earth," Cabana said. "We're going to build on our robotics precursors and build our capabilities to get there."

FORGING AHEAD

Reorg realigning work force toward strategic goals

BY STEVEN SICELOFF

One of the most far-reaching reorganizations Kennedy Space Center has ever undertaken has aligned the work force to the needs of a multi-user spaceport while preserving the unique character of the Florida center and placing employees in posts more befitting their abilities and interests said those who helped envision and implement the changes.

"I think it's been received very well," said Pat Simpkins, director of Engineering at Kennedy and the leader of the team that performed the reorganization. "It was a significant change at the end of a very significant program. I think we set up the right structure for these efficiencies to be made. It's still up to the organizations to find more efficiencies and we'll be keeping the pressure on a little bit to accomplish them."

It took more than a year to establish the reorganization structure which impacted nearly every federal employee at the center in one regard or another and became official May 17. Simpkins said one of the goals was to streamline processes where possible in recognition that future customers of the center's unique abilities are more likely to be private enterprises rather than governmental organizations.

"Kennedy needed to adapt to a changing environment to provide flexible, responsive, and affordable services that best supported the agency's strategic goals," said Bob Cabana, center director and former space shuttle commander. "The center's reorganization strategy optimizes similar functions and processes, addresses the agency's flat funding profile, considers the flight rate and life cycle phases of NASA's heavy lift vehicle, and further institutionalizes Kennedy's role in enabling commercial space markets."

Traditionally, commercial entities are on much tighter schedules and budgets than government operations, so Kennedy has to react quicker to private needs if it is to make the most of the chance to diversify its opportunities.

"We focused on how we work with our customers to be that preferred spaceport for people," said Digna Carballosa, director of Kennedy's Human Resources.

"In the context of the last five or six years, I think this is revolutionary, but in the context of the history of Kennedy Space Center, I think it's evolutionary."

PAT SIMPKINS
Director of Engineering at Kennedy Space Center, leader of reorg team

Several directorates were combined in the reorganization in an effort to tear down walls that can create unintended inefficiencies, Simpkins said. Ground Processing was incorporated into Ground Systems Development and Operations, for instance, while Public Affairs and External Relations merged into one communications organization.

"The reorganization has implemented a single interface for center services for government and current commercial users at Kennedy," Cabana said. "In addition, we have integrated similar functions to enable stronger organizations in research and technology, communications, and engineering. While many directorates have just recently begun operating under the new organization, changes like realignment of the construction of facilities function within engineering is already enabling efficiencies across a number of projects including critical modifications to High Bay 3 in the Vehicle Assembly Building."

This was not the first time the center has reset itself. The federal workforce averages about five years between reorganizations. This one is seen as more far-reaching because of the changes that are happening in the aerospace industry and approaches that are likely to accelerate in the near future. For example, the next humans scheduled to launch from Kennedy and Cape Canaveral will ride commercial rockets and spacecraft as part of the Commercial Crew Program, not NASA vehicles.

"In the context of the last five or six years, I think this is revolutionary," Simpkins said, "but in the context of the history of Kennedy Space Center, I think it's evolutionary."

The payoff is already coming into focus in a few places such as the Shuttle Landing Facility and in the Thermal Protection Support Facility (TPSF), the shop where shuttle heat shield tiles were made. Now, the building and its staff are working on projects that span a number of companies and products.

"Other centers realize the capabilities of the TPSF as world class so they are serving multiple customers for multiple centers and performing in a multi-user way," Simpkins said. "We are simply looking to enable people."

For Carballosa, the cooperation and drive from the center's highest levels made the tough, detail work of the reorganization possible.

Said Carballosa, "There was a commitment from senior leadership to articulate the goals of the reorg, mainly to share the mission and create a culture where everyone understands their role."

CENTRAL CAMPUS

A southeast view of the new Kennedy Space Center Headquarters Building. It will include numerous features to enhance its environmental efficiency and affordability. The total area of the construction site, including building, parking, roadways and walkways, will be 5.5 acres. Image credit: NASA

Concrete pilings have been driven into the ground at varying depths as a test at the construction site for the new Headquarters Building at Kennedy Space Center on May 14. The existing Headquarters Building is visible in the background. Horizontal site work is nearing completion, setting the stage for 420 concrete pilings to be driven into the ground to provide support for the building's foundation. The seven-story, 200,000-square-foot facility will anchor Kennedy's new Central Campus and house about 500 employees when complete. Photo credit: NASA.

Teams prepare to lay foundation of Kennedy's future

BY ANNA HEINEY

Behind the scenes at Kennedy Space Center, aerospace engineers are laying the foundation for the agency's new crewed space vehicles, the Orion crew module and the Space Launch System heavy-lift rocket. In parallel, construction teams are hard at work preparing the foundation for the spaceport's new Central Campus.

To the untrained eye, the five-and-a-half-acre construction zone in the heart of Kennedy's Industrial Area looks more like an outdoor festival parking lot than the future home of a new, modern headquarters building.

But the site has seen a flurry of activity in the past six months. Teams have been hard at work clearing, grading, and installing stormwater pipes and other utilities in order to support the building's construction.

Employees who have been waiting to see the rise of the seven-story, energy-efficient headquarters will soon see the poured-concrete shell of the facility beginning to taking shape.

"It's a visual thing," said Tom Wilczek, NASA's project manager for the effort, who oversees the budget and schedule, and works with the team on coordination between Kennedy Space Center, construction contractor Hensel Phelps, and architectural design firm HuntonBrady Architects of Orlando.

"Right now, people are wondering what's happening at the site. They don't see much going on. But that's how construction works. There's a lot of underground activity, including foundation pile installation," he explained.

Since the work began in mid-December 2014, efforts have been focused on horizontal site work. This included clearing the area of trees, excavation of unsuitable materials, soil compaction, and moving water in the form of underground stormwater pipes.

The next major milestone in the timeline is a significant one: 424 concrete piles will be driven into the ground to provide the support needed for the foundation. Each pile consists of two pieces that, when connected by mechanical splices, will measure 90 feet long. Piles will be clustered across the building's footprint for added strength for structural columns.

This part of the construction effort will take place at night, between the hours of 6 p.m. and 6 a.m. The area will rock with a steady drum beat as the piles are driven into the Earth.

As Kennedy Space Center transitions to a multi-user, 21st century spaceport, the new Headquarters Building will be the cornerstone of the central campus consolidation. This artist rendering depicts the ultra-modern seven-story, 200,000-square-foot facility that will house about 500 NASA civil service and contractor employees. Image credit: NASA

The massive piles are produced offsite and delivered to Kennedy. Several piles already have been driven into the ground at the site as a test. Wilczek expects all the piles to be in place this summer, and then the team will be ready to begin forming the foundation and floors.

"That's when we'll start seeing the building coming up," he said. "Ninety percent of the building is concrete, with a bit of structural steel. Since the tower and floors are all concrete, they'll form each level before moving on to the next level."

Each floor could take up to a month and a half to complete. By the end of 2015, Wilczek estimates, the majority of the concrete structure of the building should be erected.

As the contractor progresses with the concrete floor construction, the exterior finishes of the building, including windows and exterior walls, will follow.

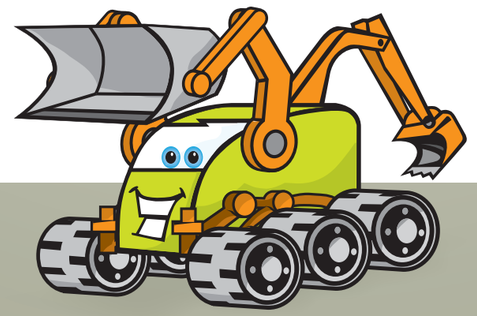
Due to the construction zone's location, reconfiguring vehicle and pedestrian traffic required some careful planning. Five dedicated trees were relocated to make way for the new building, presenting an additional challenge, as each one had to be carefully uprooted in order to preserve the root system. The trees were moved to the north side of the Operations Support Building II in Kennedy's Launch Complex 39 Area. New growth has appeared on the trees, indicating the transplantation was a success.

Once completed, the new headquarters building will house about 500 employees and anchor Kennedy's consolidated Central Campus.

Shrinking building footprints, increasing energy efficiency and focusing on long-term sustainability will reduce costs and free up resources Kennedy needs as we enter the next chapter in space exploration.

PAYDIRT

Team members from the University of Alabama in collaboration with Shelton State Community College monitor their robot miner's progress in the robot mining area May 22, 2015, from inside the command control vehicle during NASA's 6th Annual Robotic Mining Competition at the Kennedy Space Center Visitor Complex in Florida. The robot moved about, mined and deposited its loads autonomously, without the use of remote control. Photo Credit: NASA/Kim Shiflett



Technology

Collegiate miners excavate Martian soil for NASA's Robotic Mining Competition

BY LINDA HERRIDGE

Team "Astrobotics" from the University of Alabama in collaboration with Shelton State Community College received the top award, the Joe Kosmo Award for Excellence, at NASA's Sixth Annual Robotic Mining Competition awards ceremony May 22. The mining competition was May 18-22 at the Kennedy Space Center Visitor Complex.

"It was another year of hard work," said Kellen Schroeter, team lead and aerospace engineering student from the University of Alabama. "It was great to see our robot work as it was supposed to work, especially the autonomy portion."

The team also took first place in the on-site mining category, mining a total of 117.8 kilograms of regolith. Their robot accomplished all of the mining autonomously, without communication from the team or use of a remote-controlled device in the control room.

"I visited most of the teams in the mining pit and had the opportunity to see the diversity of robot designs and all of the different ideas. It was really amazing," said Bob Cabana, Kennedy Space Center director.

Purdue University placed second in the on-site mining competition, bringing in 68.3 kilograms of regolith. Their team drove 17 hours over two days from W. Lafayette, Indiana, to the space coast.

"This is a culmination of a lot of efforts," said team leader Bobby Rolley. "Our robot was fully remote-controlled, but we're going to try for autonomy next year."

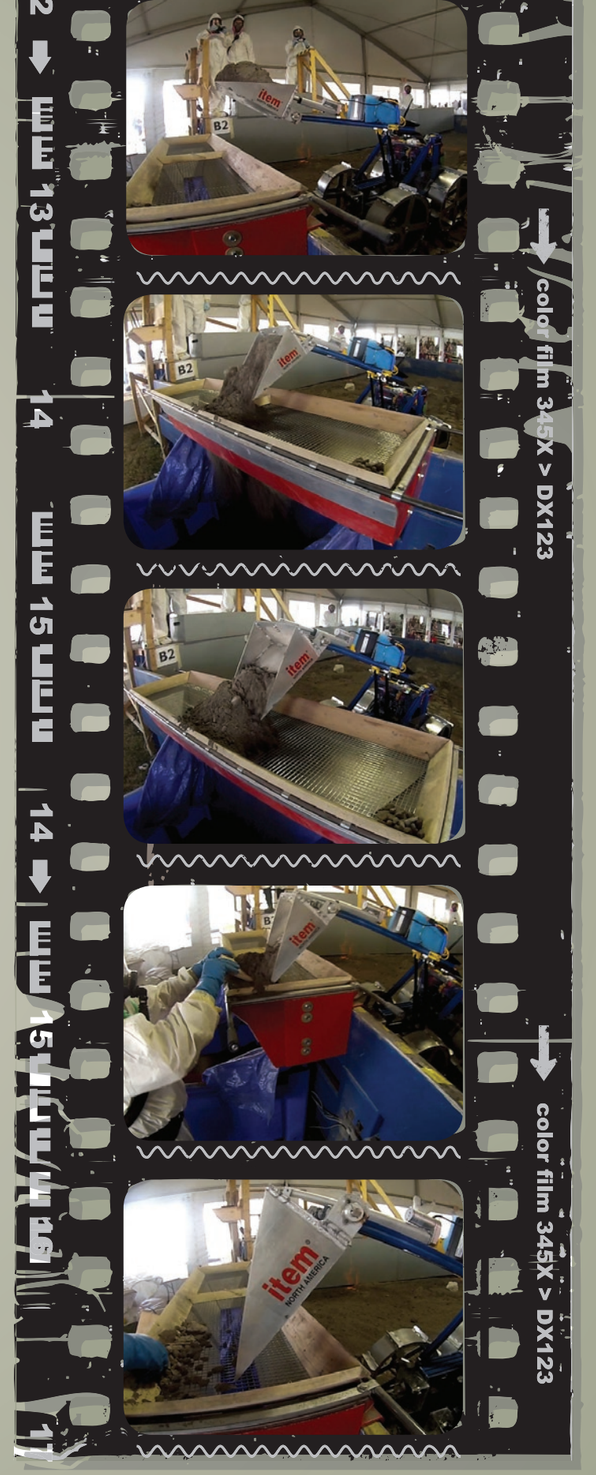
Joe Kosmo, for whom the top award is named, is a retired NASA engineer with a keen interest in robot mining. This year was his sixth year serving as a judge for the competition.

"The journey here gives the students life experiences as they bring their concepts to reality," Kosmo said. "Designing robots are a thing of the future. It's amazing how much technology has advanced over the years."

The weeklong competition featured teams of undergraduate and graduate students from 46 colleges and universities across the United States. They came from as far away as Alaska, Utah and Vermont, and as nearby as Melbourne and Orlando, with their robot miners, required systems engineering papers, display and presentation and outreach project report.

Before traveling to the space coast, each team spent up to nine months planning, designing and building robots that can traverse in a mining arena filled with simulated Martian terrain or regolith, called BP-1, excavate the regolith and deposit it into a collector bin within 10 minutes.

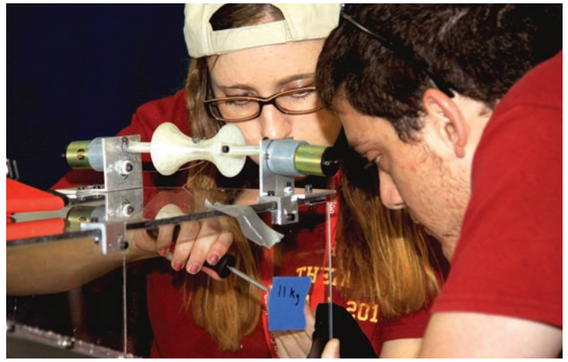
Each team had two opportunities to mine a combined total of at least 10 kilograms to qualify for the mining portion of the competition. From control rooms near the mining area, teams



Above: A robot miner traverses the simulated Martian regolith in the mining area during NASA's 6th Annual Robotic Mining Competition at the Kennedy Space Center Visitor Complex. Photo credit: NASA

Below: Members of a college team look over their robot miner during preparations in the robot pit May 18 at NASA's 6th Annual Robotic Mining Competition at the Kennedy Space Center Visitor Complex. Photo credit: NASA/Kim Shiflett

commanded their robots to perform the intricate movements required to collect the regolith and maneuver through the rocky terrain to the collector bin and complete the task. New this year to be mined was a layer of small rocks, representing ice water below the simulated regolith surface. This change brought the competition more in line with the requirements of future off-world mining missions.



Several of the teams were first-timers, including the University of Utah, who placed third in the on-site mining competition, the University of Iowa, and Kent State University, who built a robot in four months.

"We're in science heaven," said Teresa Petty, a junior studying mechanical engineering at the University of Utah. And Arten Simonyan, a senior in mining engineering from Utah said the idea of mining in space is captivating.

"The students and faculty advisors keep amazing us every year with their outstanding engineering practices, innovative robots and team spirit," said Richard Johanboeke, project manager for the Robotic Mining Competition.

Four members of the South Dakota School of Mines and Technology "Moonrockers" drove to Florida, making the 30-hour trip with their newly designed robot. They joined up with seven of their team members and one advisor for their fifth year of competition.

Rob Mueller, lead judge for the mining competition, is a NASA senior technologist in the Science and Technology Projects Division of the Spaceport Systems Branch at Kennedy.

"This year, there was significant innovation in the form of five teams that competed with multiple robots," said Mueller, "They ranged from twin robots competing concurrently, to small scouting robots that directed the excavator toward the mining zone in the regolith arena."

For their original thinking, John Brown University was awarded the Judges Innovation Award for a team of three robots, called Alpha, Beta and Charlie, that worked cooperatively to mine regolith on a local

"The robotic excavators developed by these universities for the mining competition are a way of crowdsourcing good solutions and concepts for planetary regolith excavation."

ROB MUELLER,
Lead judge for the Robotic Mining Competition

College team members make adjustments to their robot miner in the robot pit during NASA's 6th Annual Robotic Mining Competition. Photo credit: NASA

mesh wireless communications network.

Mueller said the Robotic Mining Competition is very important to NASA. Most of the resources available in space are contained in the regolith. In order to take advantage of these resources for in-situ resource utilization (living off the land), the regolith must first be excavated and then delivered to a processing plant to extract water, silicates & minerals.

"The robotic excavators developed by these universities for the mining competition are a way of crowdsourcing good solutions and concepts for planetary regolith excavation," Mueller said. "Since 2010, more than 300 robotic excavation prototype concepts have been built and demonstrated at Kennedy by many colleges and universities."

"They were magnificent," Johanboeke said. "I am looking forward to seeing how the students and their robots evolve for the 2016 competition."

NASA's Robotic Mining Competition is a Human Exploration and Operations Mission Directorate project designed to engage and retain students in science, technology, engineering and mathematics fields by expanding opportunities for student research and design. The project provides a competitive environment to foster innovative ideas and solutions that potentially could be applied to future NASA missions.

College team members prepare their robot miner for a test run in the mining arena during NASA's 6th Annual Robotic Mining Competition. Photo credit: NASA

STAR BOTS EPISODE VI

RETURN OF THE REGOLITH

Robotic Mining Competition Awards

Joe Kosmo Award for Excellence
University of Alabama in collaboration with Shelton State Community College

On-Site Mining Award
First Place — University of Alabama in collaboration with Shelton State Community College
Second Place — Purdue University
Third Place — University of Utah

Judges' Innovation Award
John Brown University

Regolith Mechanics Innovation Award
Case Western Reserve University

Autonomy Award (sponsored by Caterpillar Inc.)
University of Alabama in collaboration with Shelton State Community College

Communication Award
University of Alabama in collaboration with Shelton State Community College

Systems Engineering Paper
First Place — University of Illinois at Urbana-Champaign
Second Place — University of Alabama in collaboration with Shelton State Community College
Third Place — John Brown University
Honorable Mention — Oakton Community College

Outreach Project Award
First Place — University of North Dakota
Second Place — University of Alabama in collaboration with Shelton State Community College
Third Place — Iowa State University

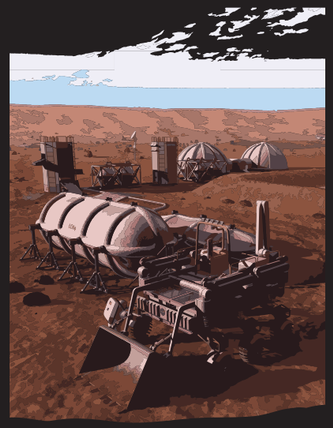
Team Spirit Award
First Place — University of Florida
Second Place — University of Akron
Third Place — University of Illinois at Chicago

Slide Presentation and Demonstration Award
First Place — University of Alabama in collaboration with Shelton State Community College
Second Place — Colorado School of Mines
Third Place — John Brown University

Engineer It! Award
Iowa State University

Social Media Award
Iowa State University

The Force was strong with these teams



NASA Administrator Charlie Bolden, left and Robert Lightfoot, the NASA associate administrator, right, share a moment with NASA engineer James Wood and his Meritorious Presidential Rank Award at NASA Headquarters in Washington, D.C., on May 5. Each year, the president recognizes and celebrates a small group of career senior executives and senior career employees who achieve results and consistently demonstrate strength, integrity, industry and a relentless commitment to excellence in public service. Award winners are nominated by their agency heads, evaluated by boards comprised of private citizens, and approved by the president. The evaluation criteria focus on leadership and results. Photo credit: NASA

NASA ANNOUNCES JOURNEY TO MARS CHALLENGE

Seeks public input on sustaining human presence on Mars

What do you need to bring, and how do you minimize the need for delivery of future supplies in order to establish a sustained human presence on a planet 140 million miles away from Earth?

NASA is embarking on an ambitious journey to Mars and Tuesday announced a challenge inviting the public to write down their ideas, in detail, for developing the elements of space pioneering necessary to establish a continuous human presence on the Red Planet. This could include shelter, food, water, breathable air, communication, exercise, social interactions and medicine, but participants are encouraged to consider innovative and creative elements beyond these examples.

Participants are asked to describe one or more Mars surface systems or capabilities and operations that are needed to achieve this goal and, to the greatest extent possible, are technically achievable, economically sustainable, and minimize reliance on support from Earth. NASA expects to make up to three awards at a minimum of $5,000 each from a total award pool of $15,000.

NASA's efforts for sending humans to Mars is well underway today, with spacecraft monitoring Mars from orbit and rovers on the surface. The International Space Station is testing systems and is being used to learn more about the health impacts of extended space travel. NASA also is testing and developing its next generation of launch and crew vehicles — the Space Launch System rocket and Orion crewed spacecraft.

NASA's two-prong approach is to build reusable space capabilities and incorporate commercial and international partners. By developing new technologies along the way and creating the systems necessary to maintain a permanent human presence in deep space, humanity will pioneer space, pushing out into the solar system to stay.

Given spacecraft limitations on weight and volume — and a minimum 500 days between resupply opportunities — innovative solutions are required for a mission to Mars that is not dependent on Earth for resources.

NASA seeks technical submissions that describe the development of capabilities and operational events necessary, in both the near- and long-term, to advance this bold journey. Submissions may consist of proposed approaches, capabilities, systems or a set of integrated systems that enable or enhance a sustained human presence on Mars. Solutions should include the assumptions, analysis, and data that justify their value. Submissions should include a process to develop, test, implement, and operate the system or capability.

Submissions will be judged on relevance, creativity, simplicity, resource efficiency, feasibility, comprehensiveness and scalability.

FOR MORE INFORMATION ABOUT THE CHALLENGE, AND DETAILS ON HOW TO APPLY, VISIT:
https://www.innocentive.com/pavilion/NASA

FOR MORE INFORMATION ABOUT NASA'S JOURNEY TO MARS, SEE:
https://www.nasa.gov/topics/journeytomars

LIVING OFF THE LAND

NASA researchers studying exploration plans

BY BOB GRANATH

When early explorers crossed vast oceans to reach new worlds, they traveled with only what they needed to get there. After arriving at their destination, the pioneers planned to live off the land. NASA engineers and scientists now are developing capabilities needed once astronauts reach destinations such as an asteroid, the moon or Mars.

At Kennedy Space Center, researchers are studying how to best practice in-situ resource utilization (ISRU), that is, harvesting and relying on available raw materials as astronauts visit deep-space destinations.

Josephine Burnett, director of Kennedy's new Exploration Research and Technology Programs organization, points out the significance of creating new capabilities.

"Pioneering space will require several game changing technologies, some of which are being developed here at Kennedy," said Burnett. "These new technological capabilities will enable NASA to become less dependent on Earth-based logistics and instead use local resources to maintain a sustained human presence in space."

According to Jack Fox, chief of the Science and Technology Projects Division of the Exploration Research and Technology Programs Directorate at Kennedy, ISRU could reduce the weight of an outfitted exploration spacecraft by 40 percent.

"The purpose of our in-situ resource utilization research is to harness these resources," he said. "When the early settlers came to North America, they brought only ax heads. They knew they could make ax handles from trees they would find when they reached their destination. We believe learning to live off available resources will significantly reduce the mass, cost and risk of near and long-term space exploration."

Fox explained that resources such as water ice, metals and regolith will be available in great supplies whether planning to work on the moon, Mars or other destinations.

A close-up view of Apollo 11 commander Neil Armstrong's boot and boot print in the lunar soil, showing the makeup of regolith on the moon. Basalt in the soft, powdery soil could be useful in building structures on the lunar surface. Photo credit: NASA/ Neil Armstrong

Rob Mueller, NASA senior technologist in the Surface Systems Office at the Kennedy Space Center, left, talks with former NASA Gemini and Apollo astronaut Buzz Aldrin during a demonstration of the Regolith Advanced Surface Systems Operations Robot, or RASSOR. The robot has been tested at Kennedy's Swamp Works. A similar spacecraft could be used to collect samples or excavate a landing pad for future landers. Photo credit: NASA/Ben Smegelsky

Regolith is a layer of loose material covering solid rock. It includes dust, soil, broken rock, and other related materials and is present on Earth, the moon, some asteroids and Mars.

One resource that is key to numerous applications is water.

"Several recent planetary missions have sent back data that points to lunar water representing a significant resource that could be used by future explorers," Fox said.

The Clementine mission, launched from Vandenberg Air Force Base in 1994, conducted a bistatic radar experiment that showed water might exist in the Shackelton crater near the lunar south pole.

Officially called the Deep Space Program Science Experiment, the objective of the Clementine mission was to test sensors and spacecraft components under extended exposure to the space environment and to make scientific observations of the moon and an asteroid.

Launched from Cape Canaveral Air Force Station in 1998, the Lunar Prospector mission detected elevated amounts of hydrogen in both of the moon's polar regions, but could not distinguish its chemical form. Other data returned during the mission also helped scientists construct a detailed map of the lunar surface composition.

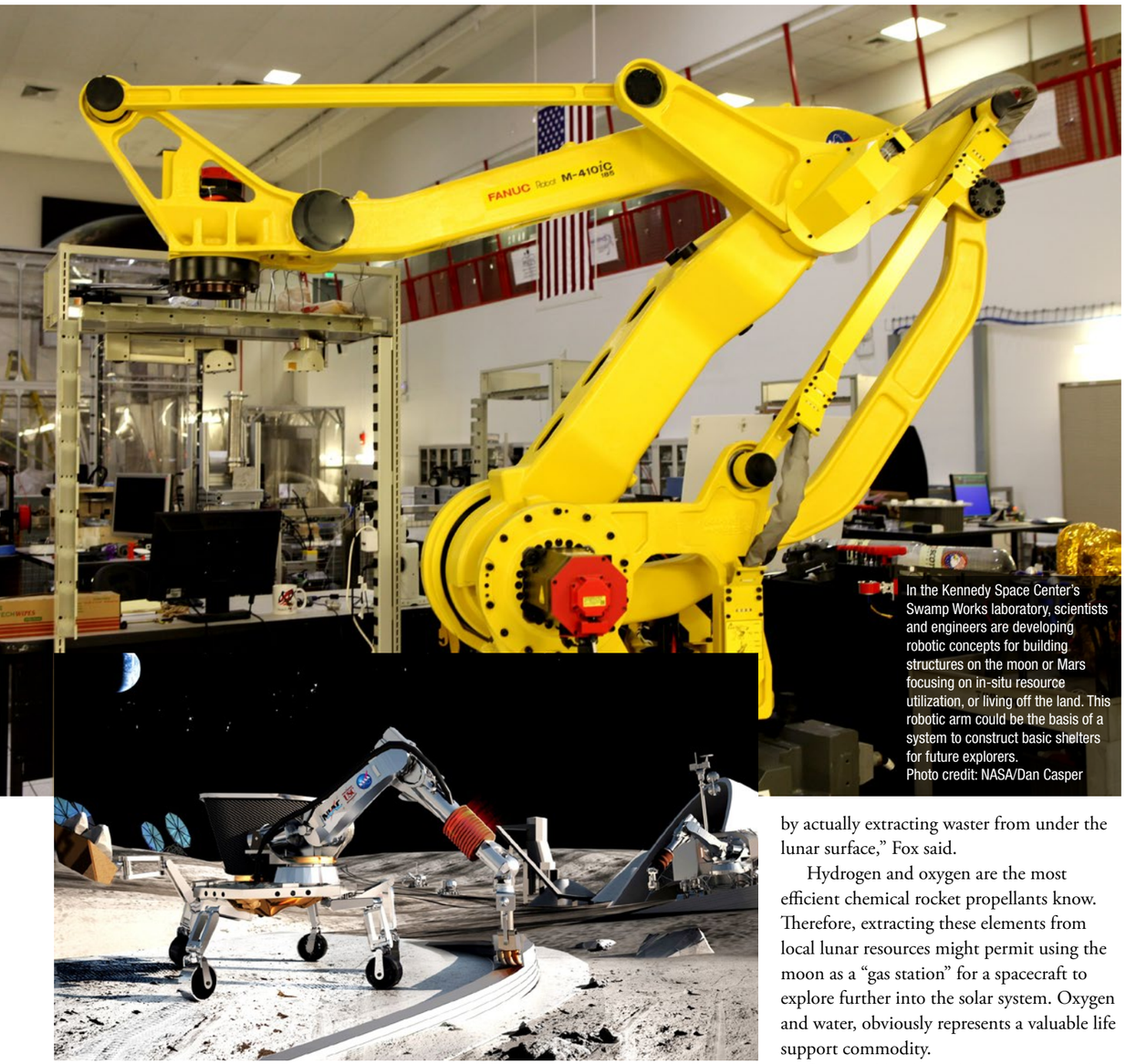
NASA's mini-RF and M^3 instruments on the Indian Space Research Organization's Chandrayaan-1 lunar orbiter provided more information on the moon's water resources. Chandrayaan-1 was India's first lunar probe, launched in 2008,

Flown from the Cape in 2009, more potential water resources were located by the Lunar Reconnaissance Orbiter and the Lunar Crater Observation and Sensing Satellite (LCROSS) missions.

Besides the obvious benefits of water itself, it is made up of hydrogen and oxygen.

"By separating these elements, we have what it takes to operate fuel cells to create electricity," Fox said. "That gives us a power plant on a distant destination."

A fuel cell converts energy from an



In the Kennedy Space Center's Swamp Works laboratory, scientists and engineers are developing robotic concepts for building structures on the moon or Mars focusing on in-situ resource utilization, or living off the land. This robotic arm could be the basis of a system to construct basic shelters for future explorers.
Photo credit: NASA/Dan Casper

This artist's concepts depicts an example of a construction strategy from Contour Crafting and University of Southern California. The approach was selected by the NASA Innovative Advanced Concepts (NIAC) Project. Contour Crafting technology has potential for building safe, reliable and affordable lunar and Martian structures, habitats, laboratories and other facilities. Contour Crafting construction systems are being developed that exploit in-situ resources and can utilize regolith as construction material. Photo credit: Contour Crafting and University of Southern California

element, such as liquid hydrogen, into electricity through a chemical reaction with liquid oxygen or another oxidizing agent.

Such technology is under development at Kennedy. The Regolith and Environment Science and Oxygen and Lunar Volatiles Extraction (RESOLVE) payload is in development for a planned Resource Prospector probe. This ISRU-driven mission features a rover that would map lunar volatiles, drill to extract samples and process water and other volatiles.

In planetary science, volatiles are chemical elements and compounds with low boiling points that are associated with a planet or moon's crust or atmosphere.

"RESOLVE is an important first step in enabling long-duration human exploration by actually extracting waster from under the lunar surface," Fox said.

Hydrogen and oxygen are the most efficient chemical rocket propellants know. Therefore, extracting these elements from local lunar resources might permit using the moon as a "gas station" for a spacecraft to explore further into the solar system. Oxygen and water, obviously represents a valuable life support commodity.

Since 1965, a fleet of robotic spacecraft have flown by, orbited and landed on Mars. Collectively, they have dramatically increased the knowledge-base about the Red Planet, helping pave the way for human pioneers.

Robotic scientific rovers now are being developed to further determine what raw materials are available and in what quantities. A prototype rover called RASSOR, for Regolith Advanced Surface System Operations Robot, has been tested at Kennedy's Swamp Works. Established to provide rapid, innovative and cost effective exploration mission solutions, Swamp Works leverages partnerships across NASA, industry and academia.

"RASSOR is designed to climb over difficult terrain," Fox said. "It has wheels with scoops that pick up regolith. It could be used to collect samples or excavate a landing pad for future landers. While the first generation RASSOR has been very successful, we now are working on RASSOR 2 which will be lighter in weight and use less energy."

As a resource, regolith shows promise for construction partly due to the extensive presence of volcanic basalt in the surface soil.

"Construction materials containing basalt and a bonding agent would be two to three times stronger in compression than normal cement concrete typically used here on Earth," Fox said. "It would be an excellent raw material for construction on the moon or Mars."

Fox noted that the strength of basalt in construction is demonstrated in second-century Roman architecture which has withstood the elements for centuries.

"We recently teamed with researchers at the Marshall Space Flight Center and the U.S. Army to study how to use regolith to build structures to support exploration of Mars," he said.

Planetary surface construction and mining tasks that may be possible using planetary regolith include launch and landing pads, equipment shelters, regolith mining for oxygen production, and water ice mining from shadowed craters.

While NASA develops ways of to use available resources at deep-space destinations, crews aboard the International Space Station (ISS) are performing human research experiments and testing advance environmental and life support systems.

The ability to grow food and recycle carbon dioxide into breathable oxygen may prove crucial for astronauts and add to the body of knowledge as they live in space for months or years at a time. A plant habitat with a large growth chamber also is being studied by Kennedy engineers to determine the affect long-duration microgravity exposure has on plants in space. Similarly, projects such as NASA's Veggie pave the way to growing and eating food in space.

The Veggie experiment is being used aboard the ISS to study the in-orbit function and performance of a new expandable plant growth facility.

To continue research into the availability and accessibility of raw materials for human exploration of Mars, NASA is planning the Mars 2020 mission, building on the success of the Curiosity mission. Scheduled for launch in 2020, the rover mission goals include detecting and characterizing ancient environments that could have harbored life, caching samples for a future sample return mission and testing the ability to extract oxygen from the Red Planet's carbon-dioxide atmosphere to prepare for future human exploration.

The Mars Oxygen ISRU Experiment (MOXIE) will test a solid oxide electrolysis technology that could be scaled up to meet human mission requirements, while the Mars Environment Dynamics Analyzer (MEDA) will improve understanding of atmospheric dust.

In addition to NASA and space agencies of other nations, Fox believes there will be future commercial interest in utilization of resources on the moon or planets.

"There are so many possibilities for mining raw materials and putting resources to work, industries may find it economically useful to join this effort," he said.

Technology investments in space can create new markets, thus stimulating growth of the nation's economy.

"We know there are solvable challenges for human missions to Mars," Fox said. "We have multiple programs in progress that will allow us to overcome the unknowns and make the best use of what we need to take along and what we'll find when we get there."

Engineers make adjustments to the second generation Regolith Advanced Surface Systems Operations Robot prior to a test at the Kennedy Space Center's Swamp Works. As a resource, regolith shows promise for construction due to the extensive presence of basalt in the surface soil. The mineral is widespread among all igneous rocks and comprises more than 90 percent of all volcanic material and it is commonly found on both the moon and Mars. Photo credit: NASA

Kennedy Space Center Visitor Complex broke ground May 29 on a next-generation attraction, Heroes and Legends, featuring the U.S. Astronaut Hall of Fame, scheduled to open in 2016. The groundbreaking ceremony featured a large gathering of astronauts, including many hall of fame members. Digging in with shovels during the groundbreaking ceremony are from left, Cheryl Hurst, director of Communication and Public Engagement, Therrin Protze, chief operating officer for the visitor complex; Jim Houser, president of Delaware North Parks and Services; Charlie Bolden, NASA administrator, Bob Cabana, center director; and Dan Brandenstein, chairman of the Astronaut Scholarship Foundation. Heroes and Legends will bring to life the stories of America's pioneering astronauts and invite guests to vicariously experience the thrills and dangers of America's earliest missions through high-tech elements and special effects. The new U.S. Astronaut Hall of Fame will serve as the culminating element of the attraction, allowing guests to interact virtually with nearly 100 astronaut heroes.
Photo credit: NASA/Kim Shiflett

ARM
ASTEROID REDIRECT MISSION

The Asteroid Redirect Vehicle (ARV), powered by advanced Solar Electric Propulsion, captures a boulder from the asteroid's surface in this artist's image. Image credit: NASA

Solar System & Beyond

NASA announces next steps on Journey to Mars: Progress on Asteroid initiative

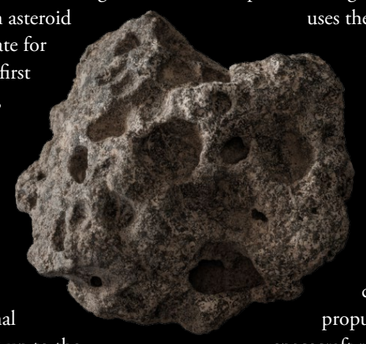
"Asteroids are a hot topic," said Jim Green, director of NASA Planetary Science. "Not just because they could pose a threat to Earth, but also for their scientific value and NASA's planned mission to one as a stepping stone to Mars."

NASA recently shared more details in its plan for its Asteroid Redirect Mission (ARM), which in the mid-2020s will test a number of new capabilities needed for future human expeditions to deep space, including to Mars. NASA also said it has increased the detection of near-Earth asteroids by 65 percent since launching its asteroid initiative three years ago.

For ARM, a robotic spacecraft will capture a boulder from the surface of a near-Earth asteroid and move it into a stable orbit around the moon for exploration by astronauts, all in support of advancing the nation's journey to Mars.

"The Asteroid Redirect Mission will provide an initial demonstration of several spaceflight capabilities we will need to send astronauts deeper into space, and eventually, to Mars," said NASA Associate Administrator Robert Lightfoot. "The option to retrieve a boulder from an asteroid will have a direct impact on planning for future human missions to deep space and begin a new era of spaceflight."

The agency plans to announce the specific asteroid selected for the mission no earlier than 2019, about a year before launching the robotic spacecraft. Before an asteroid is considered a valid candidate for the mission, scientists must first determine its characteristics, in addition to size, such as rotation, shape and precise orbit. NASA has identified three valid candidates for the mission so far: Itokawa, Bennu and 2008 EV5. The agency expects to identify one or two additional candidates each year leading up to the mission.

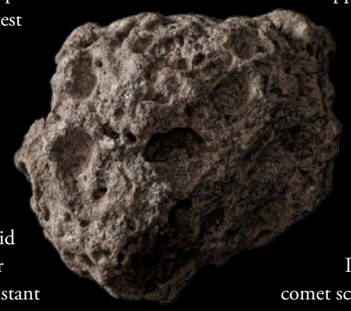


Following its rendezvous with the target asteroid, the uncrewed ARM spacecraft will deploy robotic arms to capture a boulder from its surface. It then will begin a multi-year journey to redirect the boulder into orbit around the moon.

Throughout its mission, the ARM robotic spacecraft will test a number of capabilities needed for future human missions, including advanced Solar Electric Propulsion (SEP), a valuable capability that converts sunlight to electrical power through solar arrays and then uses the resulting power to propel charged atoms to move a spacecraft. This method of propulsion can move massive cargo very efficiently. While slower than conventional chemical rocket propulsion, SEP-powered spacecraft require significantly less propellant and fewer launches to support human exploration missions, which could reduce costs.

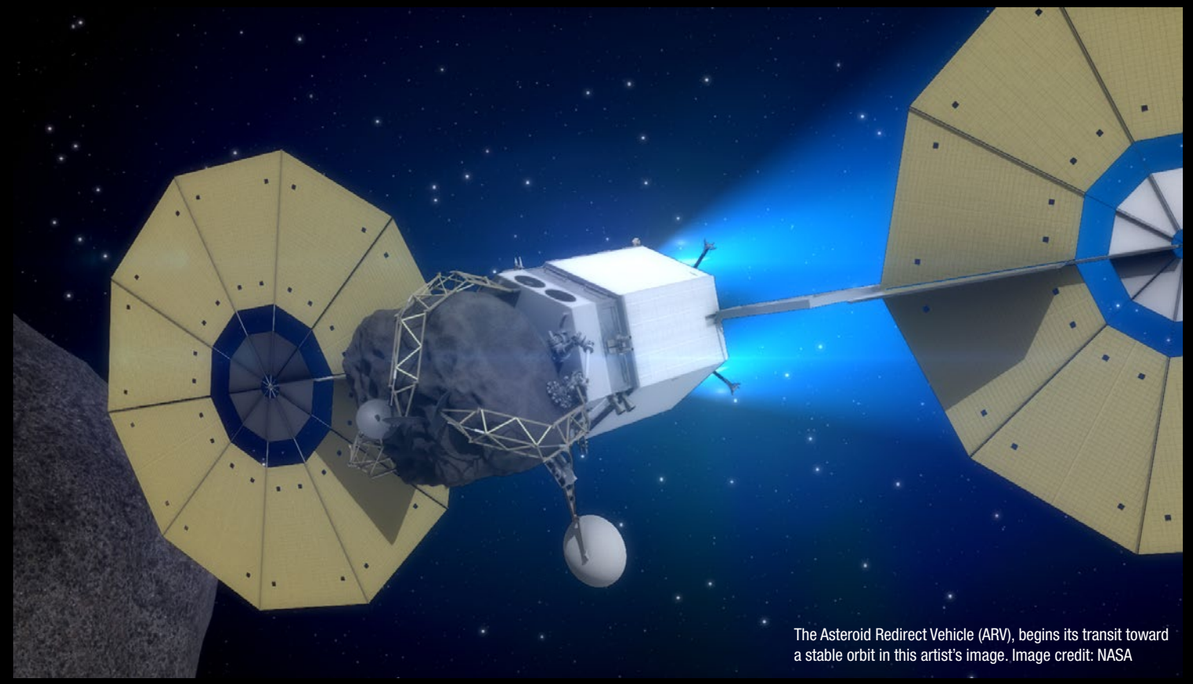
Future SEP-powered spacecraft could pre-position cargo or vehicles for future human missions into deep space, either awaiting crews at Mars or staged around the moon as a waypoint for expeditions to the Red Planet.

ARM's SEP-powered robotic spacecraft will test new trajectory and navigation techniques in deep space, working with the moon's gravity to place the asteroid in a stable lunar orbit called a distant retrograde orbit. This is a suitable staging point for astronauts to rendezvous with a deep space habitat that will carry them to Mars.



Before the piece of the asteroid is moved to lunar orbit, NASA will use the opportunity to test planetary defense techniques to help mitigate potential asteroid impact threats in the future. The experience and knowledge acquired through this operation will help NASA develop options to move an asteroid off an Earth-impacting course, if and when that becomes necessary.

In 2005, NASA's Deep Impact comet science mission tested technology that could assist in changing the course of a near-Earth object using a direct hit with a spacecraft. The ARM robotic spacecraft opens a new and second option for planetary defense using a technique called a gravity tractor. All mass exerts and experiences gravity and, in space, the gravitational attraction even between masses of modest size can significantly affect their motion. This means that by rendezvousing with the asteroid and holding a halo orbit in the appropriate direction, the ARM robotic spacecraft can slowly pull the asteroid without touching it. The effectiveness of this maneuver is increased, moreover, if mass is moved from the asteroid to the spacecraft by the capture of a boulder.



The Asteroid Redirect Vehicle (ARV), begins its transit toward a stable orbit in this artist's image. Image credit: NASA

It will take about six years for the ARM robotic spacecraft to move the asteroid mass into lunar orbit. In the mid-2020s, NASA's Orion spacecraft will launch on the agency's Space Launch System rocket, carrying astronauts on a mission to rendezvous with and explore the asteroid mass. The current concept for the crewed mission component of ARM is a two-astronaut, 24-25 day mission.

This crewed mission will further test many capabilities needed to advance human spaceflight for deep space missions to Mars and elsewhere, including new sensor technologies and a docking system that will connect Orion to the robotic spacecraft carrying the asteroid mass. Astronauts will conduct spacewalks outside Orion to study and collect samples of the asteroid boulder wearing new spacesuits designed for deep space missions.

Collecting these samples will help astronauts and mission managers determine how best to secure and safely return samples from future Mars missions. And, because asteroids are made of remnants from the formation of the solar system, the returned samples could provide valuable data for scientific research or commercial entities interested in asteroid mining as a future resources.

NASA WANTS YOU

NASA Seeks Additional Information for Asteroid Redirect Mission Spacecraft

NASA has issued a Request for Information (RFI) seeking ideas from American companies for a spacecraft design that could be used for the agency's Asteroid Redirect Mission (ARM) and a robotic satellite servicing mission in low-Earth orbit.

In the early-2020s NASA plans to launch the Asteroid Redirect Mission, which will use a robotic spacecraft to capture a large boulder from the surface of a near-Earth asteroid and move it into a stable orbit around the moon for exploration by astronauts, all in support of advancing the nation's journey to Mars.

NASA also has been studying the "Restore-L" mission concept, during which a spacecraft would use dexterous robotic systems to grapple and refuel a government satellite in low-Earth orbit. Restore-L would bring to operational status capabilities needed for future commercial satellite servicing by demonstrating technologies and reducing risk.

"Today's call for ideas from our industry partners is another important milestone for the Asteroid Redirect Mission, a critical capability demonstration mission that's part of our stepping stone approach for sending American astronauts to Mars in the 2030s," said NASA Associate Administrator Robert Lightfoot. "As part of our acquisition strategy, we're asking for more information toward the ARM spacecraft concept and also on commonality with a notional robotic satellite servicing spacecraft."

The RFI is not a request for proposal or formal procurement and therefore is not a solicitation or commitment by the government. Deadline for submissions is the end of June.

THE FULL RFI IS AVAILABLE AT:
http://www.nasa.gov/feature/arm-spacecraft-bus-request-for-information

Modifications continue inside the Multi-Payload Processing Facility (MPPF) at Kennedy Space Center. This is a close-up view of the service platform that will be used for offline processing and fueling of the Orion spacecraft and service module stack before launch. Ground Systems Development and Operations (GSDO) is overseeing the upgrades to the facility.
Photo credit: NASA/Dimitri Gerondidakis

SAFETY FIRST

SpaceX tests astronaut escape system for Dragon spacecraft

BY STEVEN SICELOFF

A loud whoosh, faint smoke trail and billowing parachutes marked a successful demonstration May 6 by SpaceX of its Crew Dragon spacecraft abort system — an important step in NASA's endeavor to rebuild America's ability to launch crews to the International Space Station from U.S. soil. The successful test of the spacecraft's launch escape capabilities proved the spacecraft's ability to carry astronauts to safety in the unlikely event of a life-threatening situation on the launch pad.

The Crew Dragon simultaneously fired its eight SuperDraco engines at 9 a.m. EDT and leapt off a specially built platform at Cape Canaveral Air Force Station's Space Launch Complex 40 in Florida. The engines fired for about six seconds, instantly producing about 15,000 pounds of thrust each and lifting the spacecraft out over the Atlantic Ocean before jettisoning its trunk, as planned, and parachuting safely into the ocean. The test lasted about two minutes from engine ignition to splashdown.

"This is a critical step toward ensuring crew safety for government and commercial endeavors in low-Earth orbit," said Kathy Lueders, manager of NASA's Commercial Crew Program. "Congratulations to SpaceX on what appears to have been a successful test on the company's road toward achieving NASA certification of the Crew Dragon spacecraft for missions to and from the International Space Station."

The flight test is a vital milestone in the company's development effort and furthers its plan to meet a major requirement for the next generation of piloted spacecraft — an escape system that can quickly and safely take crew members away from their rocket while on the pad and through their ascent to orbit. SpaceX can use the test data to help refine its aerodynamic and performance models, and its design, to help ensure crew safety throughout all phases of flight.

"SpaceX was founded with the goal of carrying people to space, and today's pad abort test represented an important milestone in that effort," said Gwynne Shotwell, SpaceX president and chief operating officer. "Our partnership with NASA has been essential for developing Crew Dragon, a spacecraft that we believe will be the safest ever flown. Today's successful test will provide critical data as we continue toward crewed flights in 2017."

The test was the first with a full-size developmental spacecraft using a complete set of eight SuperDraco engines in the demanding real-world conditions of a pad abort situation. SpaceX built the SuperDracos for pad and launch abort use. Each engine, the chambers of which are 3-D printed, burns hypergolic propellants monomethylhydrazine and nitrogen tetroxide.

More than 270 special instruments, including temperature sensors and accelerometers, which are instruments that measure acceleration, were strategically placed in and around the vehicle to measure a variety of stresses and acceleration effects. A test dummy, equipped with sensors, went along for the ride to measure the effects on the human body. To further maximize the value of the test, weights were placed inside the capsule at crew seat locations to replicate the mass of a crewed launch.

The trunk, an unpowered cylinder with stabilizing fins, detached from the spacecraft when it reached maximum altitude and fell back to Earth, while the capsule rotated as planned for a couple seconds before unfurling its drogue parachutes, which then deployed the main parachutes. Boat crews retrieved the Crew Dragon from the ocean and returned it to land for further analysis.

Spacecraft development and certification through the Commercial Crew Program is performed through a new arrangement that encourages innovation and efficiency in the aerospace industry, bringing to the process the space agency's expertise in the form of safety and performance requirements for the spacecraft, boosters and related systems.

The pad abort test is a payment milestone funded by the Commercial Crew Program under a partnership agreement established with the company in 2012. The agency awarded contracts last year to Boeing and SpaceX to build their respective systems for flight tests and operational missions to the space station. Known as Commercial Crew Transportation Capability (CCtCap) contracts, the awards allow continued work on Boeing's CST-100 and SpaceX's Crew Dragon at a pace that is determined by their respective builders, but that also meets NASA's requirements and its goal of flying crews in 2017.

"Our partners have met many significant milestones and key development activities so far, and this pad abort test provides visual proof of one of the most critical safety requirements — protecting a crew in the event of a major system failure," Lueders said.

NASA already is preparing the space station for commercial crew spacecraft and the larger station crews that will be enabled by SpaceX's Crew Dragon and Boeing's CST-100. NASA plans to use the new generation of privately developed and operated spacecraft to carry as many as four astronauts each mission, increasing the station crew to seven and doubling the amount of science that can be performed off the Earth, for the Earth.

Above: Eight SuperDraco engines boost a SpaceX Crew Dragon spacecraft away from Space Launch Complex 40 at Cape Canaveral Air Force Station in an emergency pad abort simulation. Photo credit: NASA

Opposite: A SpaceX Crew Dragon spacecraft is being prepared for a test to simulate an emergency abort from the launch pad at Space Launch Complex 40 at Cape Canaveral Air Force Station on May 5. Photo credit: NASA/Jim Grossman

LAUNCH PAD 39C

Solar System & Beyond

A new Small Class Vehicle Launch Pad, designated 39C, is being constructed in the southeast area of the perimeter of Launch Pad 39B at Kennedy Space Center. This computer-aided view shows the new concrete pad, universal propellant servicing system, and customer-provided launch mount.
Image credit: David Zeiters

New small class vehicle launch site takes shape

BY LINDA HERRIDGE

Kennedy Space Center took another step forward in its transformation into a 21st Century multi-user spaceport with the creation of a new launch pad that is designed to attract smaller aerospace companies and enable them to develop and launch their vehicles from the center.

The landscape of the center's Launch Pad 39B area is changing as construction reveals the concrete surface of a new Small Class Vehicle Launch Pad, designated 39C, which will serve as a multi-purpose site for companies to test vehicles and capabilities in the smaller class of rockets. A designated pad to test smaller rockets will make it more affordable for smaller companies to break into the commercial spaceflight market. Ground Systems Development and Operations (GSDO) is overseeing the project and working with Center Planning and Development to grow commercial space efforts at Kennedy.

"The small class market is looking for new capabilities, and we've talked to a number of companies showing some interest in Kennedy and the new launch site at pad B," said Scott Colloredo, director of Center Planning and Development.

"Along with our human, heavy class and super-heavy class Space Launch System capabilities, we want to diversify into the small class market."

Located in the southeast area of the pad B perimeter, the new concrete pad measures about 50 feet wide by about 100 feet long. In addition to the small class launch site, GSDO also has developed a universal propellant servicing system, which would provide liquid oxygen and liquid methane fueling capabilities for a variety of small class rockets.

"This small class launch vehicle pad will help to grow our commercial space efforts and give smaller companies affordable access to space," said Mike Bolger, GSDO program manager.

Jerad Merbitz, the Small Class Vehicle Element Operations manager, hopes the small class processing and launch features Kennedy has to offer, including the launch site, universal propellant servicing system, and launch control center options will attract aerospace companies to Kennedy.

Access to existing processing facilities, such as the Vehicle Assembly Building and the Multi-Payload Processing Facility, also would be a plus.

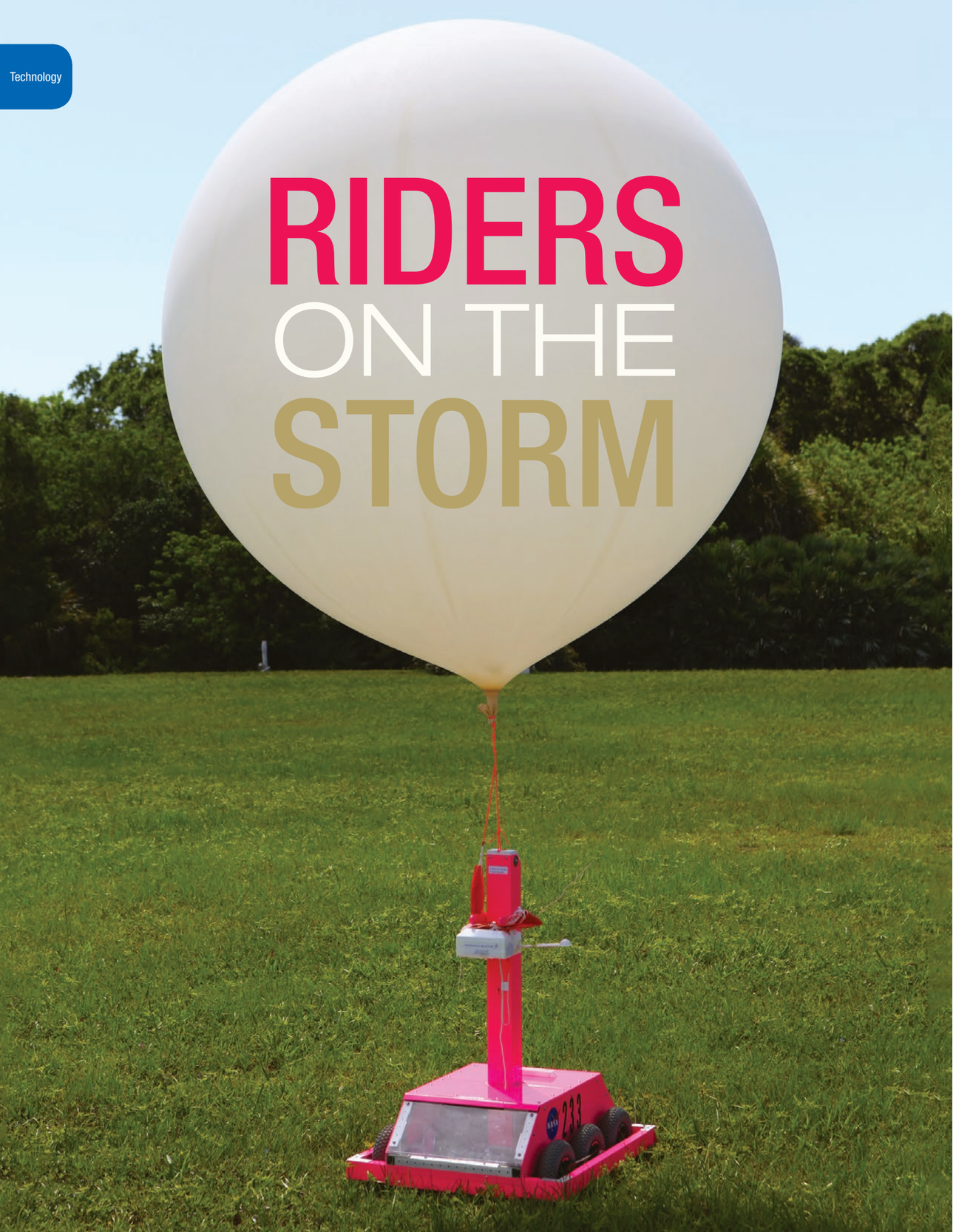
When completed, 39C could support the combined weight of a fueled launch vehicle, payload and customer-provided launch mount up to about 132,000 pounds, and an umbilical tower structure, fluid lines, cables and umbilical arms weighing up to about 47,000 pounds.

Merbitz said whether you're launching humans or payloads, it's expensive. But new developments in engines, composites, and technology have allowed commercial spaceflight to become more attainable for smaller companies.

The new launch site will be good for companies with more invested in research and development.

"At Kennedy, it's in our DNA to help these companies," Merbitz said. "It's a unique opportunity in our history, truly making this center a multi-user spaceport."

An osprey fledgling peers over the edge of its nest built on a platform in the Press Site parking lot at Kennedy Space Center. The osprey, also known as a fish hawk, is well adapted for capturing fish, which make up its entire diet. The soles of its feet are equipped with sharp, spiny projections that give the bird a firm grip on its slippery prey. Ospreys select nesting sites of opportunity, from trees and telephone poles to rocks or even flat ground. In the United States they are found from Alaska to Florida and the Gulf Coast. Osprey nests are found throughout the Kennedy Space Center and nearby Merritt Island National Wildlife Refuge. Known as a fish hawk, ospreys often can be seen flying overhead with a fish in their talons. For more information about the refuge, go to **http://go.nasa.gov/1QmkRVq**



Student-developed robot pays off during inclement weather

BY FRANK OCHOA-GONZALES

Except for Marty McFly's modified DeLorean that needed 1.21 gigawatts of electricity to travel through time in the movie "Back to the Future," launching and lightning don't mix.

With lightning season on the Space Coast reigning from June to September, any launch attempt during summer in Florida is susceptible to unruly weather.

"Any launches in that time frame are at risk," McAleenan said, "not just for the launch weather, but for the weather that's existing two, three, four hours before launch."

So high school students from around the Space Coast, NASA and officials from the 45th Weather Squadron at Cape Canaveral Air Force Station united to figure out a way to deal with dangerous weather.

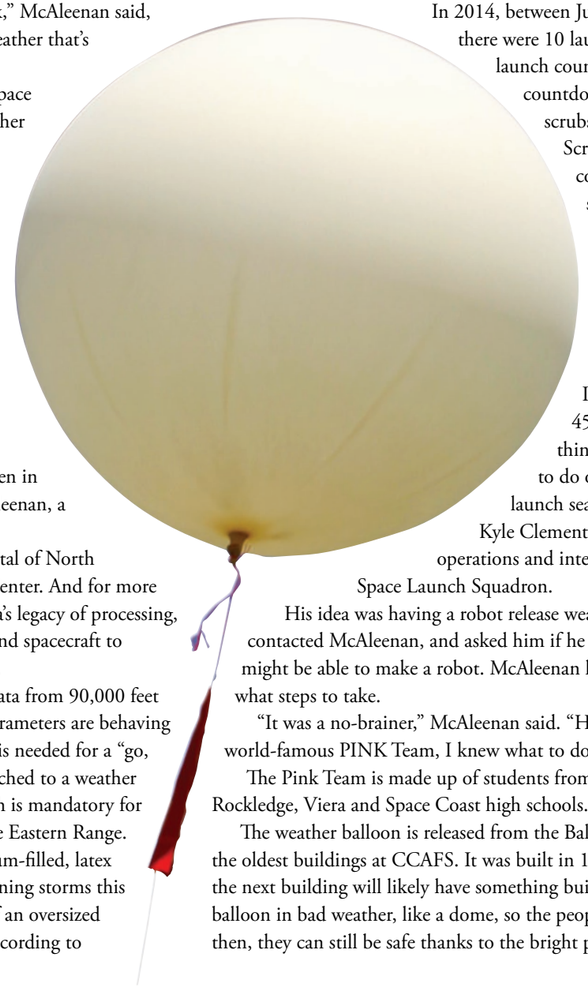
Known as the PINK Team, the students, under the guidance of mentor Andy Bradley, a NASA senior control systems engineer, built a robot. Aptly named Weatherbot, it cost about $2,000 to make, including donations and some parts on hand. This 90-pound pink robot, controlled with a PlayStation remote, allows weather balloon releases even during thunder storms.

"The Weatherbot allows balloon releases even in a Phase II lighting condition," said Mike McAleenan, a launch weather officer with NASA.

Central Florida, known as the lighting capital of North America, is home to NASA's Kennedy Space Center. And for more than 50 years, Kennedy has carried on America's legacy of processing, testing and launching a wide array of rockets and spacecraft to distant planets and other destinations in space.

In order to launch, NASA needs weather data from 90,000 feet high to assess how winds and other weather parameters are behaving throughout the atmosphere. This information is needed for a "go, no-go" call during launches. Only a sonde attached to a weather balloon by a string can provide this data, which is mandatory for both the range and the launch customer on the Eastern Range. Depending on the launch, some 10 to 15 helium-filled, latex balloons are released by hand, but during lightning storms this is deemed unsafe. The balloons start the size of an oversized yoga ball and grow as large as a small house, according to McAleenan.

There are two other types of weather balloons. One is a clear balloon and the other is metallic so it can be tracked by radar. Specialists at the Air Force station's balloon facility release two or three weather balloons a day, seven days a week. As weather data becomes critical several hours before a launch, the balloons are released more often accordingly.



In 2014, between June and September, there were 10 launches and 16 launch countdowns. Those extra countdowns were launch scrubs due to lightning.

Scrubbed launches don't come cheap. Each scrub potentially can cost, depending on payload, from $750,000 to $1 million.

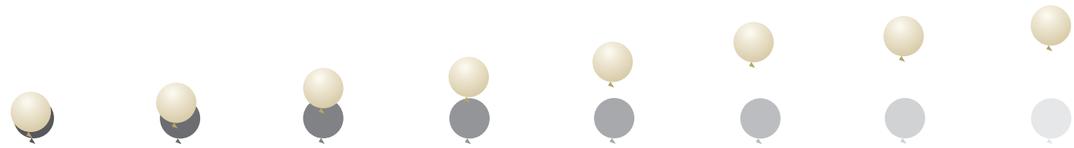
Last year was called the Year of Innovation by the 45th Space Wing — thinking of new ways to do old business. A busy launch season inspired Capt. Kyle Clements, chief of launch operations and integration for the 5th Space Launch Squadron.

His idea was having a robot release weather balloons. He contacted McAleenan, and asked him if he knew of anyone who might be able to make a robot. McAleenan knew immediately what steps to take.

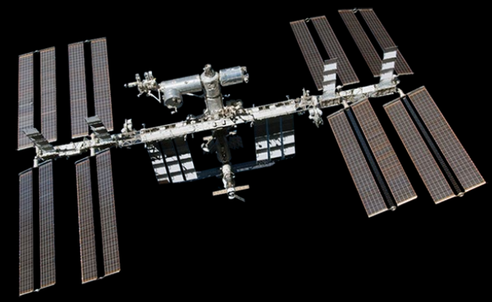
"It was a no-brainer," McAleenan said. "Having a son on the world-famous PINK Team, I knew what to do."

The Pink Team is made up of students from Cocoa Beach, Rockledge, Viera and Space Coast high schools.

The weather balloon is released from the Balloon Facility, one of the oldest buildings at CCAFS. It was built in 1956. McAleenan says the next building will likely have something built into it to release a balloon in bad weather, like a dome, so the people can stay safe. Until then, they can still be safe thanks to the bright pink WeatherBot.



LEADING LAWYER



NASA names Steve Horn Attorney of the Year

BY STEVEN SICELOFF

Three months of seven-day work weeks including a month of 17-hour days punctuated the end of 2014 for Steven Horn. As assistant chief counsel at Kennedy, Horn worked to defend the decisions by NASA's Commercial Crew Program to award contracts to Boeing and SpaceX under the Commercial Crew Transportation Capability phase. The effort was intense and draining, but equal parts rewarding for the lawyer who has since been named the agency's Attorney of the Year.

"This procurement was very complex, given the parallel space act agreements and phased acquisition and all," Horn said. "We have to bring the level of expertise that the engineers have down to a more readable level when making findings when they are going to be reviewed by someone who doesn't necessarily have that technical background. That can be difficult at times."

Horn's legal career began following his graduation from the University of Florida's Levin College of Law. After a couple years in private practice, Horn joined the Air Force where he worked in the Judge Advocate General department before going to Tinker Air Force Base in Oklahoma, where contracts and labor-related issues became his specialty. Having traveled the world in the Air Force, Horn opted to settle down in Florida, and came to work for NASA at Kennedy Space Center in 1998.

"Every day here is a challenge, whether it's contracts, space act agreements or how we're commercializing property that NASA has no present use for," Horn said. "The most rewarding thing for me, bar none, is the people I get to work with. There are some amazing engineers out here, I'm not just saying that. They blow me away every day. I like working with people smarter than me and there are a heck of a lot of people out here smarter than me and it motivates me to bring my game up. That's what I get a kick out of. It's that interaction with people and helping create solutions."

Horn is now the primary legal voice for Commercial Crew, beginning that role two years ago when he became a part of the source board to acquire services for the first American-made, human-rated spacecraft since the space shuttle. Then he helped judge how proposals by aerospace companies stacked up against NASA's requirements for Commercial Crew. Ultimately, the source board made the evaluations before NASA's hierarchy made the final selection of Boeing and SpaceX.

"The Source Evaluation Board chairwoman, Maria Collura, in my almost 30 years of work, is easily the best that I've ever come across," Horn said. "She was the glue that held the entire team together."

A couple weeks later, a protest lodged against the decision sent the board and Horn into justification mode. By the time it was complete, more than 160,000 pages had been gathered and reviewed. Ultimately, the Government Accountability Office agreed with NASA's rationale and approved the contract awards.

"I think the day the announcement was made to select two companies, it showed that all the work we had done for the past year and half as a team was correct," Horn said. "The day that we got the successful decision was a good day — a very good day for myself and for NASA."

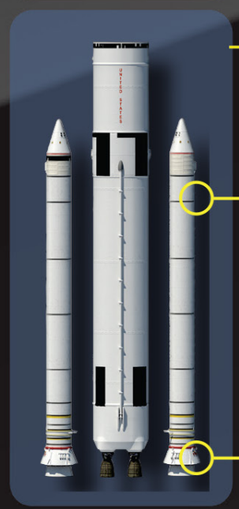
Although getting to this point with the contracts awarded and decision upheld has been a lot of work, Horn said it will be the next three years of development progress, test flights and certification that tells the team whether they got it right.

"The work's not done," Horn said. "Selecting the contractor is important, but administering the contract correctly matters just as much. We have a goal of 2017 for these flights, but it's just a goal. We need to make sure they meet NASA's requirements and are safe and cost-effective."

GROUND SYSTEMS
DEVELOPMENT & OPERATIONS

Concept of Operations

National Aeronautics and Space Administration



Launch Abort System Facility

Transported via Barge

Offline Spacecraft Processing

Multi Payload Processing Facility

Operations & Checkout Facility

Transfer Elements to Vehicle Assembly Building

Comm and Control

Command, Control & Communications Range and Firing Room

Interim Cryogenic Propulsion Stage Processing

Multi Payload Processing Facility

Turn Basin

Solid Rocket Booster Processing

Jay Jay Bridge

Railcar to Rotation Processing & Surge Facility

Rotation Processing & Surge Facility

Space Launch System Manufacturing

Hangar AF

Aft/Forward Skirt, Case Stiffner Attach Ring & Frustum Refurbishment (SLS Production Activities)

Booster Fabrication Facility

Aft Skirt, Forward Assembly & Case Stiffner Attach Ring Buildup (SLS Production Activities)

Vehicle Integration and Launch

Vehicle Assembly Building High Bay 3

Vehicle Integration & Test

Crawler-Transporter 2

Transport to Pad

Mobile Launcher

Launch Complex 39B

LIFT-OFF

Landing and Recovery

Crew Module Landing

Crew Module & Crew Recovery

West Coast Recovery & Transport to Kennedy Space Center for Deservicing

SP-2014-03-089-KSC

U.S. ASTRONAUT HALL OF FAME

CLASS OF 2015

U.S. Astronaut Hall of Fame Welcomes Quartet of Space Heroes

BY FRANK OCHOA-GONZALES

Former astronaut Hoot Gibson gave his wife, Rhea Seddon, an awesome 34th wedding anniversary present underneath space shuttle Atlantis -- he inducted her as part of the 14th class of astronauts into the U.S. Astronaut Hall of Fame.

John Grunsfeld, Steven Lindsey, Kent Rominger and Seddon were enshrined during a ceremony May 30 at the Kennedy Space Center Visitor Complex on the 25th anniversary of the Hall of Fame.

The event marked the first time an astronaut has inducted their spouse into the Astronaut Hall of Fame.

"Well, this has never happened before," Gibson said. "This is really a thrill for me."

JOHN GRUNSFELD

Grunsfeld was selected as a NASA astronaut in March 1992. A five-flight veteran, he has logged more than 58 days in space, including 58 hours and 30 minutes of extravehicular activity (EVA) over the course of eight spacewalks.

Grunsfeld's first flight was STS-67 aboard Endeavour as a mission specialist, launching March 2, 1995.

"My first real launch was off the kitchen counter when I was 5," Grunsfeld said.

Grunsfeld served as flight engineer on his second flight, STS-81 Atlantis.

Grunsfeld returned to space aboard Discovery on Dec. 19, 1999. As a mission specialist on STS-103, the third Hubble Space Telescope (HST) servicing mission, Grunsfeld performed two of the three EVAs.

STS-109 Columbia launched March 1, 2002, and was the fourth HST servicing mission.

STS-125 Atlantis, launched May 11, 2009, was the fifth HST servicing mission.

Grunsfeld currently is NASA's associate administrator of the Science Mission Directorate in Washington, D.C.

"We learned how to do it is put together wonderful teams of people to achieve great things," Grunsfeld said. "We've been able to solve these high-performance challenges with teams of people with vision, drive and enthusiasm. I feel privileged to have been a member of some of those teams."

STEVE LINDSEY

Steven Lindsey was selected as a NASA astronaut in March 1995. A veteran of five space shuttle flights, Lindsey has logged more than 1,510 hours in space.

Lindsey first flew in space Nov. 19, 1997, as pilot of STS-87 Columbia.

As pilot of Discovery, Lindsey returned to space alongside Sen. John Glenn on STS-95, which launched Oct. 29, 1998.

Lindsey's first mission as commander was STS-104, the 10th International Space Station (ISS) assembly mission.

Lindsey next commanded STS-121 Discovery which launched July 4, 2006, the second Return to Flight test mission after the Columbia mishap.

STS-133 saw Lindsey commanding the 39th and final flight of Discovery, launched on Feb. 24, 2011.

Lindsey currently is the senior director for Sierra Nevada Corporation's Space Explorations Systems.

"I think it's important to preserve the history, to tell the story, to inspire next generations to come forward and take our place and do better than we did," Lindsey said. "If we can do something to inspire kids to see the value of hard work and the importance of working toward something that you're passionate about, then it's all worth it. It's not about us."

KENT ROMINGER

"As a young kid I was very inspired by the Mercury 7 astronauts," Rominger said. "I can't believe I am part of a group that includes my heroes. I've loved being part of the team."

Rominger was selected by NASA to become an astronaut in 1992. A veteran of five space shuttle missions, he has logged more than 1,600 hours in space.

Rominger first launched as pilot of Columbia on Oct. 20, 1995, on the STS-73 mission.

Rominger returned to space aboard Columbia once more as pilot of STS-80. The mission launched Nov. 19, 1996.

STS-85 Discovery, Rominger's third mission as pilot, launched Aug. 7, 1997.

Rominger's first mission as commander was STS-96 Discovery, which launched on May 27, 1999.

During his final mission, STS-100 Endeavour, which launched April 19, 2001, Rominger commanded a diverse international crew, representing the United States, Russia, Canada and Italy.

Rominger retired from NASA in 2006 to accept a position with ATK Launch Systems.

"This group is all about giving back to our community. We're trying to promote STEM (science, technology, engineering and math) education to better our space program, our nation and ideally, the entire globe."

RHEA SEDDON

"Being part of the first group of women astronauts, there was a particular pressure on us to do well," Seddon said. "If I did something wrong or made a big mistake, people wouldn't say, 'Rhea Seedon made a mistake,' they would say 'women couldn't do this job.' There was extra pressure on us back then."

Rhea Seddon, M.D., is one of NASA's first female astronauts, who served as a mission specialist and payload commander on three life sciences missions.

Seddon was selected by NASA in January 1978 and became an astronaut in August 1979 as part of the first U.S. astronaut class to include women. A three-flight veteran, she has logged more than 722 hours in space.

Seddon lifted off aboard Discovery on her first mission, STS-51D, on April 12, 1985. She returned to space on June 5, 1991, on STS-40 Columbia, again serving as mission specialist.

As payload commander on her third and final flight, STS-58, which launched Oct.18, 1993, Seddon was in charge of all science activities aboard Columbia.

Now with LifeWings Partners, she acts as a consultant to healthcare institutions across the United States.

This year marks the 25th anniversary of the U.S. Astronaut Hall of Fame, which was founded in 1990 by the six remaining Mercury astronauts as a place where space explorers could be remembered. This year's inductees comprise the 14th group of astronauts named to the U.S. Astronaut Hall of Fame, bringing the total number of members to 91.

Technicians remove a side thermal window from one of Orion's tile panels inside the Neil Armstrong Operations and Checkout Building high bay at Kennedy Space Center on May 15. The tile panels with thermal windows intact were removed from Orion in the Launch Abort System Facility after the spacecraft returned to Kennedy in late December. All of the windows are being removed and disassembled for post-flight inspection for any signs of micrometeoroid or orbital debris impacts or other potential glass damage. Orion launched aboard a United Launch Alliance Delta IV Heavy rocket on Exploration Flight Test-1 on Dec. 5, 2014. After a two-orbit, 4.5 hour mission, Orion splashed down in the Pacific Ocean and was retrieved by NASA, Lockheed Martin and the U.S. Navy. The spacecraft was secured in the well deck of the USS Anchorage and brought to Naval Base San Diego, where it was offloaded, secured in a container and transported back to Kennedy for analysis. Orion will next launch atop the agency's Space Launch System rocket. The spacecraft will help enable missions to an asteroid and on toward Mars. For more information, visit www.nasa.gov/orion. Photo credit: NASA/Dimitri Gerondidakis

50TH ANNIVERSARY OF AMERICAN SPACEWALKING

50 YEARS
#SuitUp

What Is a Spacewalk?

Any time an astronaut gets out of a vehicle while in space, it is called an extravehicular activity, or EVA. The more common term is spacewalk.

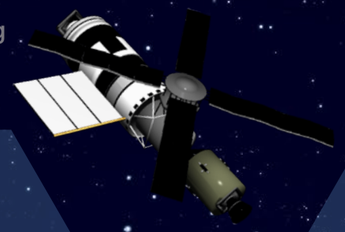
1965 Ed White
1st American Spacewalk

GEMINI
9 SPACEWALKS

1971
Al Worden
First deep space EVA

APOLLO
4 SPACEWALKS
14 MOONWALKS

1972
Gene Cernan
Jack Schmitt
Longest Moonwalk
7 hours 37 Minutes



1969
Neil Armstrong
Buzz Aldrin
1st Moonwalk

SKYLAB
10 SPACEWALKS

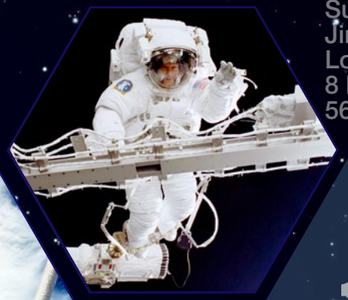
1973
Owen Garriott
Retrieves film from Skylab's Apollo Telescope Mount

1984
Bruce McCandless
1st Untethered EVA

SPACE SHUTTLE
82 SPACEWALKS

1984
Kathy Sullivan
First spacewalk performed by an American woman

1992
Rick Hieb
Tom Akers
Pierre Thuot
Satellite Rescue



2001
Susan Helms
Jim Voss
Longest EVA
8 hours
56 Minutes

2006
Robert Curbeam Jr.
Christer Fuglesang
Assembly of the ISS

ISS
187 SPACEWALKS ... and counting

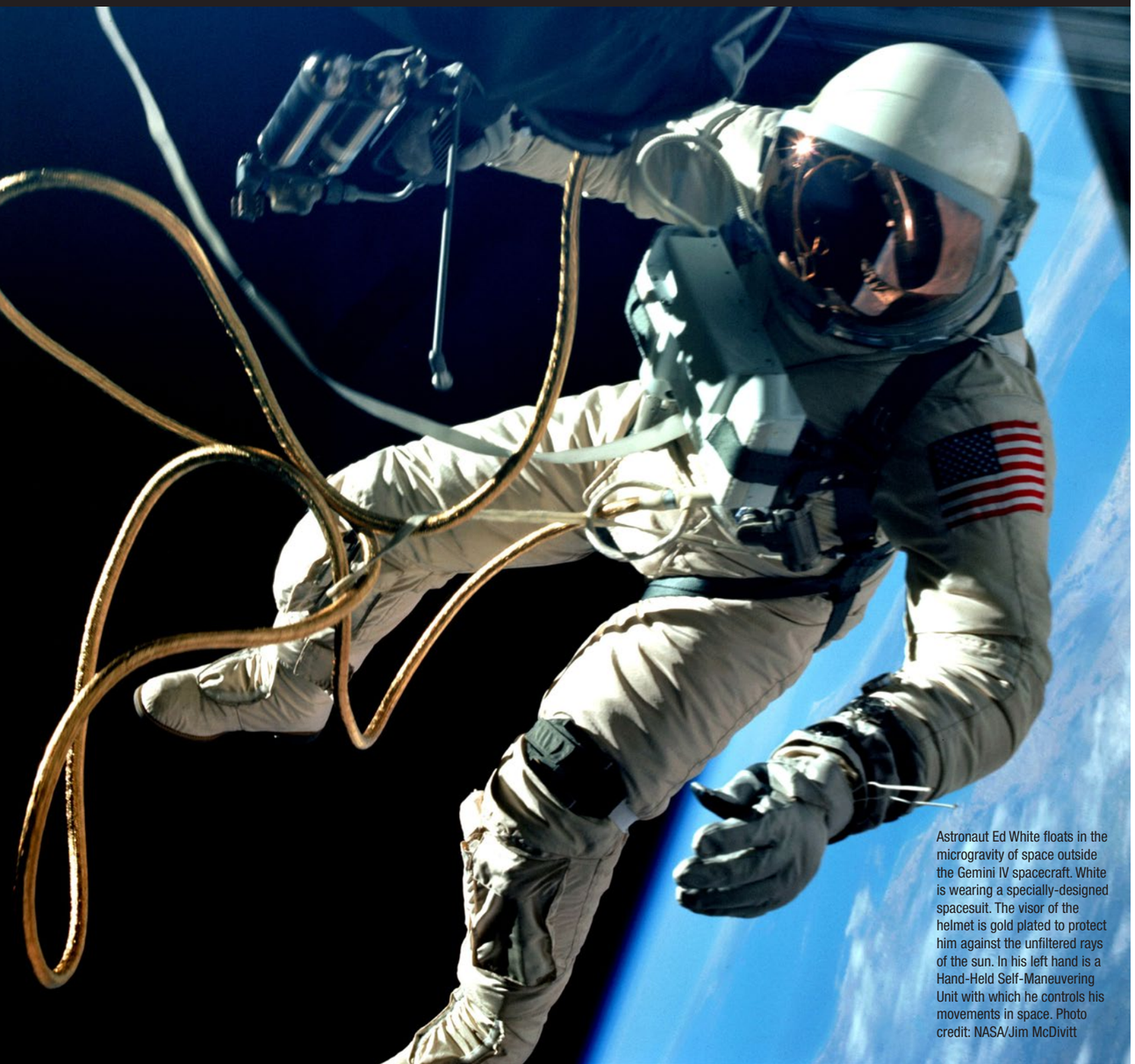
Asteroids and Mars

By exploring an asteroid, NASA will be able to test a number of new capabilities needed for future human deep-space expeditions including the Journey to Mars

MARS
THE NEXT GIANT LEAP

PROJECT GEMINI

PART 2



Astronaut Ed White floats in the microgravity of space outside the Gemini IV spacecraft. White is wearing a specially-designed spacesuit. The visor of the helmet is gold plated to protect him against the unfiltered rays of the sun. In his left hand is a Hand-Held Self-Maneuvering Unit with which he controls his movements in space. Photo credit: NASA/Jim McDivitt

Gemini IV — Learning to Walk in Space

BY BOB GRANATH

Building on the success of the first piloted Gemini mission, NASA prepared to launch its most ambitions flight to date – Gemini IV. During June 1965, two astronauts would not only stay in orbit four days, one would attempt America's first spacewalk. It was another example of advancing technology enabling new avenues of exploration.

Since the Soviet Union launched the world's first satellite, Sputnik 1, in Oct. 4, 1957, the United States had been attempting to catch up in the space race. The Russians passed the Americans again on March 18, 1965, when cosmonaut Alexei Leonov performed the first spacewalk during the one-day Voskhod 2 mission. However, with Gemini IV, NASA was quickly catching up.

Air Force pilots Jim McDivitt and Ed White were selected as the crew for the upcoming flight. Like John Young on Gemini III, they were members of the agency's second group of astronauts. McDivitt went on to command Apollo 9, the first piloted test of the lunar module, and he later became manager of Lunar Landing Operations and Apollo Spacecraft Program manager.

During Gemini IV, White would become the first American to venture outside his spacecraft for what is officially known as an extravehicular activity, or EVA. The world has come to know it as a spacewalk. In the following years, it was a skill that allowed Apollo explorers to walk on the moon and American astronauts and their partners from around the world to build the International Space Station.

EVA is an example of NASA's sustained investments to mature capabilities required to reach challenging destinations such as an asteroid, Mars and other planets.

Agency administrator Charlie Bolden spoke of the 50th anniversary of Gemini IV and how its legacy remains a crucial part of spaceflight today.

"This year we celebrate 50 years since Edward White left his Gemini capsule to become America's first spacewalker," said Bolden speaking in his "State of NASA" address at the Kennedy Space Center on Feb. 2. "It was only a few years later that we landed humans on the moon."

Christopher Kraft Jr., assistant director for Flight Operations, at his console in the Mission Control Center during Gemini-4 spaceflight. He served as mission director and as a flight director. Gemini 4 was the first flight to be followed by the mission control at the new Manned Spacecraft Center in Houston. Photo credit: NASA

Four days of Gemini IV would not only come close to the Russian record, but almost double NASA astronauts' previous time in space.

Before June 1965, the longest American spaceflight was Gordon Cooper's 34 hours in space during May 1963 aboard Mercury 9. Soviet cosmonaut Valery Bykovsky spent five days in orbit a month later aboard Vostok 5.

Lifting off from Launch Pad 19 at Cape Kennedy (now Cape Canaveral) Air Force Station on June 3, 1965, Gemini 4 was the first flight to be followed by the mission control at the new Manned Spacecraft Center

(MSC) in Houston. MSC grew out of the Space Task Group formed soon after the creation of NASA and originally located at the Langley Research Center in Virginia. Beginning with Project Mercury, that complex was the center of U.S. human spaceflight training and management through Gemini III.

The 1,620-acre MSC complex became the primary flight control center for all subsequent U.S. manned space missions from Project Gemini forward. On Feb. 19, 1973, the center was renamed in honor of the late U.S. president and Texas native, Lyndon B. Johnson.

The new setup also required Julian Scheer, NASA's assistant administrator for Public Affairs, to develop a new approach to how the agency reported mission progress to the world. The original plan was to have MSC Public Affairs Director Paul Haney do both the launch and mission commentary from Houston, just like he did for Gemini III. For all previous Mercury and Gemini missions the control center was at the Cape Kennedy launch site.

Scheer directed that Jack King, NASA's first chief of Public Information at the Florida spaceport, would do the countdown commentary from the Pad 19 blockhouse at the Cape with Haney taking over from Houston at liftoff. This set the precedent for all future human spaceflights with the exception that, beginning with Apollo, the commentary hand-off would be at the point when the rocket cleared the launch tower.

Once in orbit, the first order of business was an attempt to rendezvous with the Titan II booster rocket's second stage. It proved more difficult than originally thought. There were only two running lights on the stage, and there was no radar on board to give a precise range to the target. McDivitt then decided to concentrate on the more important EVA objective.

While flying over the tracking station in Hawaii, White pulled the handle to open his hatch.

"Okay, I'm out," said White. He floated outside the capsule attached by an umbilical cord tether providing oxygen and communications from the spacecraft.

"You look beautiful, Ed," said McDivitt as he began taking pictures of White tumbling around outside his window.

"I feel like a million dollars," White said.

As White floated outside Gemini IV, he used a Hand-Held Maneuvering Unit, informally called a "zip gun." The device expelled pressurized oxygen to provide thrust for controlling his movements outside the capsule.

"The gun works great, Jim," White said to his command pilot. "It's very easy to maneuver with the gun. The only problem I have is that I haven't got enough fuel. I was able to maneuver myself around the front of the spacecraft and maneuver right up to the top of the adapter, and came back into Jim's view."

McDivitt and White also had time for some sightseeing, reporting back to capsule communicator Gus Grissom in mission control.

"Hey, Gus, we're right over Houston," said White. "We're looking right down on Galveston Bay."

At the end of the 20-minute spacewalk, White was exuberant.

"This is the greatest experience," he said. "It's just tremendous."

During the remainder of the four-day mission, McDivitt and White conducted 11 scientific experiments. One investigation involved spacecraft navigation using a sextant to measure their position using the stars. The objective was to investigate the feasibility of using this technique for lunar flights on the Apollo program.

Another focused on photography with a 70-millimeter Hasselblad camera taking images of the weather and terrain on Earth. From the agency's earliest efforts, NASA has been an innovative leader in studies of Earth science.

Gemini IV command pilot Jim McDivitt, leading, and pilot Ed White, walk up the ramp at Launch Pad 19 during countdown for their four-day mission.
Photo credit: NASA

At left and next page:
Astronaut Ed White floats in the microgravity of space outside the Gemini IV spacecraft. White is wearing a specially-designed spacesuit. The visor of the helmet is gold plated to protect him against the unfiltered rays of the sun. In his left hand is a Hand-Held Self-Maneuvering Unit with which he controls his movements in space.
Photo credit: NASA/Jim McDivitt

Gemini IV astronauts Ed White, left, and Jim McDivitt talk to officials on the USS Wasp recovery aircraft carrier on June 7, 1965. Photo credit: NASA

Re-entry took place June 7, 1965, on the 62nd orbit, with the spacecraft landing 43 miles short of the intended landing target, about 390 miles east of Cape Kennedy. The crew of a helicopter from the aircraft carrier USS Wasp was able to see them land.

Minutes after pickup, McDivitt and White stepped off the helicopter onto the deck of the recovery ship, receiving a tremendous ovation from the sailors on the deck of the Wasp.

Following the recovery of Gemini IV, Dr. George Mueller, NASA’s associate administrator for Manned Space Flight, had high praise for those supporting the mission.

“I would like to congratulate the launch crew and the launch vehicle and spacecraft checkout crew for doing a splendid job,” he said. “I particularly want to say the support for the range, for the spacecraft and for the launch vehicle were tremendous.”

EDITOR’S NOTE: This is the second in a series of feature articles marking the 50th anniversary of Project Gemini. During 1965 and 1966, NASA developed many innovative solutions that dramatically advanced the agency’s capabilities for living and working in space. In August, read about Gemini V and developing the technology for long-term spaceflight.

In case you missed Part One of the Gemini series you can read it in the March issue of Spaceport Magazine by clicking here.

NASA spinoff

DHS, NASA technology helps save four in Nepal earthquake disaster

Four men trapped under as much as 10 feet of bricks, mud and other debris have been rescued in Nepal thanks to a new search-and-rescue technology developed in partnership by the Department of Homeland Security's (DHS) Science and Technology Directorate (S&T) and NASA's Jet Propulsion Laboratory (JPL). The device called FINDER (Finding Individuals for Disaster and Emergency Response) uses microwave-radar technology to detect heartbeats of victims trapped in wreckage. Following the April 25 earthquake in Nepal, two prototype FINDER devices were deployed to support search and rescue teams in the stricken areas.

"The true test of any technology is how well it works in a real-life operational setting," said DHS Under Secretary for Science and Technology Dr. Reginald Brothers. "Of course, no one wants disasters to occur, but tools like this are designed to help when our worst nightmares do happen. I am proud that we were able to provide the tools to help rescue these four men."

The men had been trapped beneath the rubble for days in the hard-hit village of Chautara. David Lewis, president of one of S&T's commercial partners, R4 Inc. out of Eatontown, New Jersey, arrived in Nepal with two prototype FINDER devices April 29 to assist in the rescue efforts. He joined a contingent of international rescuers from China, the Netherlands, Belgium and members of the Nepali Army in Northern Nepal. Using FINDER, they were able to detect two heartbeats beneath each of two different collapsed structures, allowing the rescue workers to find and save the men.

Above: The Finding Individuals for Disaster and Emergency Response (FINDER) prototype technology can locate individuals buried under rubble in disaster scenarios. This photo is from a previous test. Credits: NASA/JPL-Caltech/DHS

Opposite: The FINDER device is operated using a hand-held device, such as a laptop, running the FINDER software. The user can specify a minimum and maximum range for detecting heartbeats in the vicinity. Credits: NASA/JPL-Caltech/DHS

"NASA technology plays many roles: driving exploration, protecting the lives of our astronauts and improving — even saving — the lives of people on Earth," said Dr. David Miller, NASA's chief technologist at NASA Headquarters in Washington. "FINDER exemplifies how technology designed for space exploration has profound impacts to life on Earth."

The FINDER device was demonstrated May 7 at the Virginia Task Force One Training Facility in Lorton, Virginia. At this event, which was scheduled long before the Nepali earthquake, S&T and JPL demonstrated the technology with the assistance of members of Virginia Task Force One. They also announced its official transition to commercial enterprise where the devices can be manufactured and made available to search and rescue teams around the world.

FINDER has previously demonstrated capabilities of detect people buried under up to 30 feet of rubble, hidden behind 20 feet of solid concrete, and from a distant of 100 feet in open spaces. A new "locator" feature has since been added to not only provide search and rescue responders with confirmation of a heartbeat, but also the approximate location of trapped individuals within about five feet, depending on the type of rubble.

The technology works by beaming microwave radar signals into the piles of debris and analyzing the patterns of signals that bounce back. NASA's Deep Space Network regularly uses similar radar technology to locate spacecraft. A light wave is sent to a spacecraft, and the time it takes for the signal to get back reveals how far away the spacecraft is. This technique is used for science research, too. For example, the Deep Space Network monitors the location of the Cassini mission's orbit around Saturn to learn about the ringed planet's internal structure.

The Deep Space Network, managed by JPL, is an international network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe. The network also supports selected Earth-orbiting missions.

"Detecting small motions from the victim's heartbeat and breathing from a distance uses the same kind of signal processing as detecting the small changes in motion of spacecraft like Cassini as it orbits Saturn," said James Lux, task manager for FINDER at JPL.

"In disaster scenarios, the use of radar signals can be particularly complex," DHS and NASA explained. "Earthquakes and tornadoes produce twisted and shattered wreckage, such that any radar signals bouncing back from these piles are tangled and hard to decipher. JPL's expertise in data processing helped with this challenge. Advanced algorithms isolate the tiny signals from a person's moving chest by filtering out other signals, such as those from moving trees and animals."

COURTESY OF
NASA'S JET PROPULSION LABORATORY

Mining judges monitor a robot during NASA's 6th Annual Robotic Mining Competition at the Kennedy Space Center Visitor Complex. The competition is a NASA Human Exploration and Operations Mission Directorate project designed to engage and retain students in science, technology, engineering and mathematics fields by expanding opportunities for student research and design. Photo credit: NASA/Francisco Martin

National Aeronautics and Space Administration

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

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