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Space Administration

Kennedy Space Center's

SPACEPORT MAGAZINE

NASA'S JOURNEY TO MARS

KENNEDY SPACE CENTER'S

SPACEPORT MAGAZINE

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Cover: A fleet of robotic spacecraft and rovers already are on and around Mars, dramatically increasing our knowledge about the Red Planet and paving the way for future human explorers. The Mars Science Laboratory Curiosity rover measured radiation on the way to Mars and is sending back radiation data from the surface. This data will help us plan how to protect the astronauts who will explore Mars. Future missions such as the Mars 2020 rover, seeking signs of past life, also will demonstrate new technologies that could help astronauts survive on Mars. Image credit/NASA

Back Cover: NASA astronaut Reid Wiseman (pictured here) and European Space Agency astronaut Alexander Gerst completed the first of three spacewalks for the Expedition 41 crew aboard the International Space Station on Oct. 7. The spacewalkers worked outside the space station's Quest airlock for 6 hours and 13 minutes, relocating a failed cooling pump and installing gear that provides backup power to external robotics equipment. Flight Engineer Barry Wilmore of NASA operated the Canadian robotic arm and served as the spacewalk coordinator. Photo credit: NASA/ESA/Alexander Gerst

NASA'S LAUNCH SCHEDULE

Date: Nov. 23
Mission: Expedition 42 Launch to the International Space Station
Description: Launching on Soyuz 41 from the Baikonur Cosmodrome, Kazakhstan, Soyuz 41 will take Terry Virts and Samantha Cristoforetti to the International Space Station.

Date: No Earlier Than December
Mission: Fifth SpaceX Commercial Resupply Services Flight with Cloud-Aerosol Transport System (CATS)
Description: Launching from Cape Canaveral Air Force Station, Florida. SpaceX CRS-5 will deliver cargo and crew supplies to the station. It also will carry CATS, a laser instrument to measure clouds and the location and distribution of pollution, dust, smoke, and other particulates in the atmosphere.

Date: No Earlier Than Dec. 4
Mission: Flight Test of NASA's New Orion Spacecraft
Description: NASA's Orion spacecraft will launch this year atop a Delta IV Heavy rocket from Cape Canaveral Air Force Station's Space Launch Complex 37. The Orion Flight Test will evaluate launch and high speed re-entry systems such as avionics, attitude control, parachutes and the heat shield.

THE SPACEPORT MAGAZINE TEAM

Editorial
Managing Editor ..... Chris Hummel
Editor..... Frank Ochoa-Gonzales
Assistant Editor..... Linda Herridge
Copy Editor ..... Kay Grinter

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

I am KENNEDY SPACE CENTER

National Aeronautics and Space Adminstration

NASA

Nicole Delvesco

I am a senior system accountant in the Office of the Chief Financial Officer. I oversee the Government Travel Credit Card program for Kennedy Space Center. I review system data, reconciliations, and reports to ensure accuracy and timeliness and to provide agencywide policy and oversight on a variety of travel accounting and financial reporting matters.

The most exciting part of my job is knowing that I contribute to the U.S. space program. I have worked for NASA for more than 23 years at two centers, Goddard Space Flight Center and Kennedy. I love working with people at NASA because each employee has a tremendous amount of knowledge in their field of expertise, and we all come together to make NASA's mission successful. It takes all of us performing our duties with excellence. It is inspiring to be part of that team!

I also am co-chair of one of the Employee Resource Groups at Kennedy. The Disability Awareness and Action Working Group (DAAWG) has been a passion of mine for the past 15 years. I am honored to have the opportunity to encourage and inspire other employees to achieve their highest capability. I enjoy helping remove barriers for employees with disabilities and enhancing awareness for the workforce.

I feel privileged to be part of the NASA family!

EXPLORATION ON A GRAND SCALE

MAVEN continues Mars exploration started by Mariner 4 probe 50 years ago

BY BOB GRANATH

When the Mars Atmosphere and Volatile Evolution, or MAVEN, spacecraft arrived at the Red Planet on Sept. 21, it marked the continuation of exploration of one of Earth's nearest celestial neighbors that began 50 years ago. In 1964, the Mariner 4 probe became the first to successfully fly by Mars, opening the way for future human exploration.

MAVEN was launched from Kennedy Space Center atop an Atlas V rocket on Nov. 18, 2013. Following a roughly 10-month trip of more than 442 million miles, the spacecraft was inserted into an elliptical orbit on Sept. 21.

MAVEN will study the Martian upper atmosphere while orbiting the planet. Mission goals include determining how the Martian atmosphere and water, presumed to have once been substantial, were lost over time. Spacecraft previously visiting Mars returned data indicating that liquid water once flowed on the Mars surface. However, water now cannot exist extensively on the Martian surface due to the low atmospheric pressure and surface temperatures. MAVEN will observe the upper atmosphere, and drivers of variability from the Sun, in order to estimate the loss of the Martian atmosphere and water over time.

The primary mission includes five "deep-dip" campaigns in which MAVEN's lowest orbital altitude will be from 93 miles to about 77 miles. These measurements will provide information at the point where the upper and lower atmospheres meet, giving scientists a full profile of the upper tier.

"NASA has a long history of scientific discovery at Mars and the safe arrival of MAVEN opens another chapter," said John Grunsfeld, astronaut and associate administrator of the NASA Science Mission Directorate at the agency's Headquarters in Washington. "MAVEN will complement NASA's other Martian robotic explorers -- and those of our partners around the globe -- to answer some fundamental questions about Mars and life beyond Earth."

The exploration of Mars began a half-century ago with the Nov. 28, 1964, launch of Mariner 4, the first successful mission to the Red Planet. It was one of the great early successes for NASA, returning the first photographs of another planet from deep space.

Approximately 40 minutes prior to closest approach on July 15, 1965, at a range of 6,118 miles, the television camera began taking the first of 21 photographs.

A report by the Jet Propulsion Laboratory-California Institute of Technology team that managed the flight stated that the surface was pockmarked much like the moon.

"There were more than 70 clearly distinguishable craters ranging in diameter from 4 to 120 km (2.5 to 74.5 miles)," the report said. "It seems likely that smaller craters exist; there also may be still larger craters, since Mariner 4 photographed, in all, about one percent of the Martian surface."

A little more than an hour after the encounter, Mariner 4 dipped behind Mars, as viewed from Earth, in order to refract its radio signals through the Martian atmosphere. Data indicated that the atmospheric pressure on the surface was quite low.

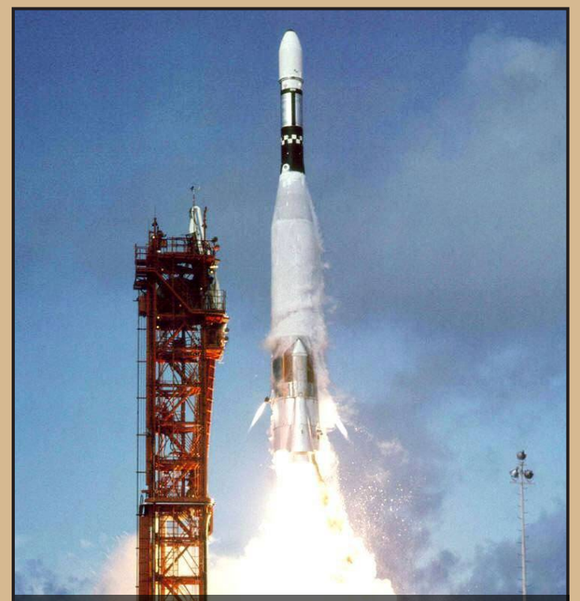
The probe detected daytime surface temperatures of about minus 148 degrees Fahrenheit. A very weak radiation belt, about 0.1 percent that of the Earth's, also was discovered by Mariner 4.

In addition to unlocking key information about how to safely deliver future missions to the Martian surface, the spacecraft far outlasted its planned eight-month mission. Mariner 4 remained in solar orbit, continuing long-term studies of the solar wind and making coordinated measurements with the Mariner 5 mission to Venus. Contact finally was lost Dec. 21, 1967.

Since Mariner 4, the lure of the Red Planet remains, with numerous spacecraft being launched to further explore Mars by the United States, the Soviet Union/Russia, Japan, Great Britain, the European Space Agency, India and the People's Republic of China. MAVEN makes the 16th successful American probe dispatched to Mars.

On Nov. 13, 1971, Mariner 9 became the first spacecraft to be placed in orbit around another planet. After enduring months of dust storms, Mariner 9 sent back clear pictures of the Martian surface.

Vikings 1 and 2 were the first spacecraft to soft land on Mars and to successfully perform a mission returning data and photographs of the landscape. Viking 1 once held the record for the



NASA's Mariner 4 spacecraft lifts off Launch Pad 12 at Cape Canaveral Air Force Station atop an Atlas Agena rocket Nov. 28, 1964. One of the great successes of the early American space program, Mariner 4 took the first photos of another planet from space. Photo credit: NASA

longest Mars surface mission of 2,307 days or 2,245 sols (Martian days). The record was broken by the Opportunity Rover on May 19, 2010. The term "sol" refers to the duration of a solar day on Mars, equal to 24 hours and 39 minutes on Earth.

NASA's Mars Pathfinder landed a base station with a roving probe on Mars on July 4, 1997. The 23-pound wheeled robotic Mars rover, named Sojourner, made measurements of the elements found in the rocks and the Martian soil.

Among the most successful robotic explorers have been the twin Mars Exploration Rovers, known as Spirit and Opportunity. The rovers were designed to search for and characterize a wide range of rocks and soils that hold clues to past water activity on Mars.

Mission planners initially hoped the two rovers would operate for 90 sols. After that time, both Spirit and Opportunity still had plenty of life, and multiple mission extensions kept Spirit functioning until March 22, 2010. Opportunity continues to operate, having traveled almost 25 miles across the Martian surface.

Launched by NASA to Mars on Nov. 26, 2011, the Mars Science Laboratory (MSL) landed the Curiosity rover on Aug. 6, 2012. The compact car-sized rover is about twice as long and five times as heavy as Spirit and Opportunity and carries over ten times the mass of scientific instruments.

MSL carried out a more accurate landing than previous spacecraft to Mars, aiming for a small target landing ellipse of only 4.3 by 12.4 miles, in the 96-mile-diameter Gale Crater. Curiosity now is investigating Mars' habitability, studying its climate and geology and collecting data in advance of a human expedition to the Red Planet.

The MSL Curiosity rover measured radiation on the way to Mars and is sending back data that will help in planning how to protect astronauts who travel to Mars.

Since Mariner 4's arrival in 1965, a fleet of robotic spacecraft and rovers has landed on and orbited Mars. Collectively, they have dramatically increased the knowledge-base about the Red Planet, helping pave the way for future human explorers.

For many years, science fiction writers told fanciful stories about encounters with Martians. However, the first detailed study of the engineering challenges of an actual trip to the Red Planet was published by Wernher von Braun in his 1952 book, The Mars Project.

NASA's Curiosity rover used the Mars Hand Lens Imager to capture this set of 55 high-resolution images, which were stitched together to create this selfie. Taken on Oct. 31, 2012, it shows the rover at the site where the mission's first scoop sampling took place. Four scoop scars can be seen in the regolith in front of the rover. The base of Gale Crater's 3-mile-high sedimentary mountain, Mount Sharp, rises in the right side of the frame Image credit: NASA/Jet Propulsion Laboratory-Caltech

Von Braun began writing the manuscript in 1947 while working for the U.S. Army at Fort Bliss, in El Paso, Texas. At the time, he was helping launch rockets to the edge of space at the nearby White Sands Proving Ground in New Mexico.

In his book, von Braun suggested that a mission to Mars would require a fleet of spacecraft, noting that when Christopher Columbus sailed from Spain in 1492, it was with three ships.

"So it is with interplanetary exploration," he wrote, "it must be done on a grand scale."

American television audiences gained their first view of the possibility of human space travel in a series of episodes of Walt Disney's popular show, Disneyland. Between 1955 and 1957, Disney presented what he called "science factual" episodes, including one entitled "Mars and Beyond."

"Together, von Braun (the engineer) and Disney (the artist) used the new medium of television to illustrate how high man might fly on the strength of technology and the spirit of human imagination," wrote Mike Wright, the Marshall Space Flight Center's historian, in an article on the Disney and von Braun collaboration.

NASA's Orion spacecraft and Space Launch System (SLS) rocket are designed to achieve that goal to expand human presence in deep space and enable exploration of new destinations in the solar system.

Orion is intended to meet the evolving needs of our nation's space program for decades to come. It will

This artist concept depicts NASA's Space Launch System, which will be the most powerful rocket ever built. It is designed to boost the agency's Orion spacecraft on deep-space missions, including to an asteroid and, ultimately, to Mars. Image credit: NASA/Marshall Space Flight Center

take crews of up to four astronauts farther than they've ever gone before, enabling missions to asteroids and, eventually, to Mars.

Scheduled for December, the upcoming Exploration Flight Test 1 (EFT-1) will be the first test flight for Orion.

NASA's SLS, a heavy-lift launch vehicle that will help provide that new capability for human exploration, will boost Orion off the planet in the first integrated flight test, Exploration Mission 1. SLS is designed to be flexible, launching spacecraft for both human and cargo missions.

One of the first steps to develop the "grand scale" technology needed for such an expedition will come from NASA's initiative to use advanced solar electric propulsion to robotically capture an asteroid and redirect it to a stable orbit in the Earth-moon system. Astronauts then would launch aboard an Orion spacecraft atop an SLS rocket to collect samples of and explore the relocated asteroid.

NASA Administrator Charles Bolden believes that the latest spacecraft to arrive at Mars, along with those that preceded it, are the stepping stones needed to reach the ultimate goal of human exploration.

"As the first orbiter dedicated to studying Mars' upper atmosphere, MAVEN will greatly improve our understanding of the history of the Martian atmosphere, how the climate has changed over time, and how that has influenced the evolution of the surface and the potential habitability of the planet," Bolden said. "It also will better inform a future mission to send humans to the Red Planet in the 2030s." SpM

Rocket Roll

Delta IV heavy travels to launch pad for Orion's first flight test

BY LINDA HERRIDGE

The United Launch Alliance (ULA) Delta IV Heavy rocket for Exploration Flight Test-1 rolled out of the Horizontal Integration Facility near Space Launch Complex 37 in the evening Sept. 30, and made the trek to the launch pad at Cape Canaveral Air Force Station in Florida. The rocket was carried to the launch complex by an Elevating Platform Transporter.

Early morning the next day, the nearly 180-foot-tall launch vehicle carefully was lifted into the vertical position using the Fixed Pad Erector and then raised into the Mobile Service Tower on the pad.

"We've been working toward this launch for months, and we're in the final stretch," said Kennedy Space Center Director Bob Cabana. "Orion is almost complete and the rocket that will send it into space is on the launch pad. We're 64 days away from taking the next step in deep-space exploration."

About 15 ULA engineers, technicians and representatives from safety, quality, security and other groups ensured that the launch vehicle arrived safely at the pad.

"This is a tremendous milestone and gets us one step closer to our launch later this year," said Tony Taliancich, ULA's director of East Coast Launch

This close-up view shows the United Launch Alliance Delta IV Heavy rocket for Exploration Flight Test-1 being raised into the vertical position at the pad at Space Launch Complex 37 at Cape Canaveral Air Force Station in Florida on Oct. 1. The Delta IV Heavy is being readied to launch Orion on its first flight test. Liftoff of Orion on the first flight test is planned for December. Photo credit: NASA/Daniel Casper

Operations. “The team has worked extremely hard to ensure this vehicle is processed with the utmost attention to detail and focus on mission success.”

For this rollout, NASA’s Launch Services Program (LSP) participated in ULA’s Component Responsible Engineer Readiness Review in Denver, Colorado, and the Launch Vehicle On Stand Test Readiness Review at the ULA launch site.

“We review launch site processing and preparations to make sure everything that is necessary to proceed with putting the rocket on the pad has been completed,” said Merri Anne Stowe, LSP Fleet Systems Integration Branch. “We serve in an advisory role for the EFT-1 mission. We’re there to help only if issues come up.”

While the Delta IV waits on the launch pad, workers have been busy at several Kennedy facilities preparing the Orion spacecraft for its flight.

On Sept. 11, the Lockheed Martin-built Orion spacecraft, attached to its service module, moved from the Operations and Checkout Building to the Payload Hazardous Servicing Facility. The spacecraft was fueled with ammonia, hydrazine and high-pressure helium ahead of its December flight test.

The spacecraft then was moved to the Launch Abort System Facility on Sept. 28 where the Launch Abort System was installed around Orion.

Orion’s first flight test is scheduled for Dec. 4. During the mission, the spacecraft will travel 3,600 miles in altitude above the Earth and return home at speeds of 20,000 miles per hour. The spacecraft will endure temperatures near 4,000 degrees Fahrenheit. The flight’s goals are to test many of the systems critical to Orion, including the heat shield, the launch abort system and the parachute system.

A team of NASA, Lockheed Martin and U.S. Navy workers, with coordination from the agency’s Ground Systems Development and Operations Program, will retrieve Orion, the forward bay cover and the parachute system after splashdown in the Pacific Ocean.

An uncrewed Orion will launch atop NASA’s Space Launch System on Exploration Mission 1 in 2018. The spacecraft will serve as the exploration vehicle that will carry astronauts to space and provide safe re-entry from deep-space missions.

“There has been a lot of excellent work done to get to this point and it’s exciting to see the hardware coming together at the launch pad,” Stowe said. “I’m looking forward to eventually seeing astronauts launched from Kennedy again.” SpM

“There has been a lot of excellent work done to get to this point and it’s exciting to see the hardware coming together at the launch pad. I’m looking forward to eventually seeing astronauts launched from Kennedy again.”

– Merri Anne Stowe

The United Launch Alliance Delta IV Heavy rocket for Exploration Flight Test-1 is lifted to the vertical position Oct. 1 at the pad at Space Launch Complex 37 at Cape Canaveral Air Force Station in Florida. Photo credit: NASA/Daniel Casper.

BREAKING GROUND

Breaking ground Oct. 7, from left are Dan Tweed, director for facilities, Center Operations; Steve Belflower of HuntonBrady Architects; Nancy Bray, director of the Center Operations Directorate; Center Director Bob Cabana, Kirk Hazen of Hensel Phelps; and Kelvin Manning, Kennedy's associate director. Photo credit: NASA/Kim Shiflett

Construction of new headquarters building underway

BY ANNA HEINEY

With a flick of their shovels, the leaders and builders of Kennedy Space Center's future broke ground Oct. 7 for a new headquarters building that will serve as the centerpiece for the Florida spaceport's new Central Campus.

Kennedy is transforming into a modernized, multi-user launch center capable of accommodating government and commercial partners. The new headquarters exemplifies the economic and environmental benefits of consolidating aging facilities into an efficient, sustainable campus that helps set the stage for the center's future.

"This is a sign that the Kennedy Space Center is continuing to move forward in our transition," said Kennedy Director Bob Cabana.

"This facility is going to reduce our operating costs significantly as we consolidate, as we tear down these old facilities that we have, and move toward a greener Kennedy Space Center."

The ceremony was held in a green space between the existing headquarters and another historic spaceport facility, the Neil Armstrong Operations and Checkout Building.

When the time came to dig into the soil, Cabana was joined by Kelvin Manning, Kennedy's associate director; Nancy Bray, director of Kennedy's Center Operations Directorate; Dan Tweed, director for facilities, Center Operations Directorate; Steve Belflower, vice president of HuntonBrady

Architects of Orlando; and Kirk Hazen, southeast district manager and vice president of Hensel Phelps, the construction contractor.

Carrying the space theme, each floor of the 200,000-square-foot headquarters building will be accented with the colors of planets in our solar system, with soothing Earth-toned break rooms. Energy-efficient LED lighting will illuminate offices throughout the facility. Cost-saving, environmentally friendly innovations continue outside with reflective roofing materials, dual electric vehicle battery charging stations in parking areas, and landscaping with native plants to reduce the need for watering.

"This new facility will take us into the next 50 years of space exploration," said Bray.

Throughout the course of the entire Central Campus construction project, 450,000 square feet will be built, but about 900,000 will be taken down, Bray explained.

"The Central Campus will provide us more energy efficiency and will be more cost effective, and that allows us to put more money into our mission," she added.

In addition to its financial and environmental savings, the new headquarters building also is meant to inspire, reminding employees and visitors alike of the center's role in space exploration.

"We were charged with designing an iconic building, and I think we achieved it," Belflower said.

The building's design depicts a tower at the east end, topped by a soaring roofline reminiscent of a sail – which Belflower explained was the intent.

"The sail element harkens back to the heritage of Kennedy Space Center and all of the launches and missions that began here," he said.

When the new headquarters opens, it will house about 500 NASA civil servicecivil service and contractor employees in a state-of-the-art workspace befitting the accomplishments to come. Construction is expected to last through late 2016. SpM

"To the team that helped make this happen, thank you, I cannot wait to see the final results in a couple of years."
–Bob Cabana, *Kennedy Space Center Director*

The artist renderings depict the seven-story, 200,000-square-foot headquarters building under construction at NASA's Kennedy Space Center. Image credit: NASA

COUNTING DOWN

Time ticking down on historic launch clock

BY FRANK OCHOA-GONZALES

Father Time has taken its toll on NASA's Kennedy Space Center countdown clock.

Years of hurricanes and harsh Florida humidity and sunshine have taken their toll. Before year's end, the historic icon will be replaced.

The countdown clock at Kennedy's Press Site is considered one of the most-watched timepieces in the world and may only be second in popularity to Big Ben's Great Clock in London, England. It also has been the backdrop for a few Hollywood movies.

"It is so absolutely unique -- the one and only -- built for the world to watch the countdown and launch," said Timothy M. Wright, IMCS Timing, Countdown and Photo Services. "From a historical aspect, it has been very faithful to serve its mission requirements."

The exterior of the clock is original to the Apollo era, but the interior mechanism has been updated. Designed by Kennedy engineers and built by Kennedy technicians in 1969, the countdown clock has become harder to maintain because parts are getting older and more difficult to obtain.

"Over the years, we've had to keep circuits up with all the lightning in the area," Wright said. "We've also had to keep it dry inside with dehumidifiers."

Not including the triangular concrete and aluminum base, the famous landmark is nearly 6 feet (70 inches) high, 26 feet (315 inches) wide and 3 feet deep.

Each numerical digit (six in all) is about 4 feet high and 2 feet wide. Each digit uses 56 40-watt light bulbs, the same ones found at the local hardware store. There are 349 total light bulbs in the clock, including the +/- sign (nine) and pair of colons (four).

In 2004, the clock was damaged by Hurricane Charlie. It was then that NASA decided it was time for an upgrade.

As the sun rises and paints a colorful skyline across Kennedy Space Center on May 16, 2011, media set up cameras at the countdown clock in the Launch Complex 39 area before the launch of space shuttle Endeavour on the STS-134 mission.
Photo credit: NASA/Troy Cryder

The design of a more modern multimedia display, similar to the screens seen at sporting venues, is in the works. The display, which comes at a cost of $280,000, will provide images from multiple sources, as well as the countdown launch time. Also, streaming video will be an option.

The new display is very similar in size, with the screen being nearly 26 feet wide by 7 feet high. While not true high-definition, the video resolution will be 1280 x 360.

“Visually it will be much brighter and support whatever mission it is called upon,” Wright said. “Hopefully the new display will be accepted like its predecessor.”

The countdown clock always has been tied visually with the flagpole 34 feet away. Officially called “The Press Site: Clock and Flag Pole,” the pair was listed in the National Register of Historic Places on Jan. 21, 2000. They are historically associated with all U.S. space program launches since the moon landings more than 40 years ago.

The clock is controlled from the Launch Control Center (LCC) by the Timing and Imaging Technical Support Group, also known as the “timing crew.” From the LCC, technicians monitor and distribute the official time to NASA facilities, including the firing rooms.

Before a launch, the launch director performs the traditional call to stations and the countdown clock is activated and begins to count down eventually to T-zero in hours, minutes and seconds. After launch, the clock runs forward, recording mission-elapsed time (MET).

The digital countdown timer has ticked toward some of mankind’s greatest feats launched from American soil. They include:

- Apollo 12 moon-landing mission, November 1969
- Skylab, May 1973
- The Apollo–Soyuz Test Project, July 1975
- First space shuttle launch, April 1981
- First post-Challenger shuttle mission, September 1988
- Hubble Space Telescope launch, April 1990
- John Glenn’s launch aboard shuttle Discovery, October 1998
- First post-Columbia shuttle mission, July 2005
- Final space shuttle mission, STS-135, July 2011

The clock also has been used to countdown numerous planetary probe and uncrewed NASA launches that lift off from nearby Cape Canaveral Air Force Station. The last launch on which the countdown clock was used was the Sept. 25 liftoff of the SpaceX CRS-4 resupply mission to the International Space Station. That may prove to be the clock’s final mission.

Wright said, “I do believe it was always able to come through -- although sometimes with some hard work -- when it really counted.”

Another sign of the times is the Central Instrumentation Facility (CIF) Time Station, built in 1965, was permanently turned off Oct. 23 at 9:40 a.m. The time station provided 24/7 timing, countdown, reference frequency and first-motion codes and signals to the Industrial Area facilities and remote sites. But because of the new design to install GPS time-code generators in major facilities in the Industrial Area, the timing function of the CIF is no longer required. The countdown distributed from the CIF now has moved to the LCC Master Time Station, and the Reference Frequency distribution has moved to the CD&SC Remote Time Station to support mission requirements in Kennedy’s Industrial Area.

“With its functional operation now dispersed to multiple facilities with the new design,” Wright said, “the signals run through the GPS Satellite Time and Frequency Systems, and we have a more accurate way of delivering and receiving the signal.”

According to Luis Berrios, Kennedy’s Exhibits and Artifacts Manager, Kennedy has requested to acquire the countdown clock from the agency’s Artifact Working Group (AWG) at NASA Headquarters for possible display at the Kennedy Space Center Visitor Complex.

“Many feel this clock is as much of an icon as Apollo and Shuttle,” Berrios said. “At the visitor complex, it would ignite the magic surrounding a launch, and begin the countdown to explore Kennedy Space Center as part of the entry experience for the guests of the visitor complex.” SpM

DID YOU KNOW?

The use of a countdown to a rocket launch was invented by Fritz Lang, a German film director, in his 1929 silent film, "Woman in the Moon." Before this, rocket launches in film and other media were preceded by a count-up or no introduction. According to William Ley, a German science fiction writer and space advocate, the idea of a countdown preceding a launch was so successful, German rocket scientists, including Hermann Oberth and Wernher von Braun, adopted the procedure in their research and tests.

Overcoming Obstacles

Overcoming Obstacles

Power of the Human Spirit' drives DAAWG event

What does it take to get special needs students into Space Camp at the U.S. Space and Rocket Center in Huntsville, Alabama? A teacher with a lot of determination who was seeking new ways to help his students learn and overcome any challenge.

Michael Kersjes, a retired teacher and football coach from Grand Rapids, Michigan, is the author of the book "A Smile as Big as the Moon," which describes his efforts to get the first group of 20 students with disabilities into Space Camp in 1989. The book later was made into an Emmy award-winning Hallmark Hall of Fame movie.

Kersjes brought his motivational message to Kennedy Space Center in October for National Disability Employment Awareness Month. Organized by the center's Disability Awareness and Action Working Group (DAAWG) and led by co-chairwomen Nicole Delvesco and Jessica Conner, Kersjes' presentation focused on the "Power of the Human Spirit" in dealing with obstacles and how to reach a common purpose. -- Linda Herridge

To read the complete story, visit http://go.nasa.gov/1Dlwy8l

a look online

more online

SELF-SUFFICIENCY

Innovative automated system that makes loading propellants more efficient soon will be put to test

BY BOB GRANATH

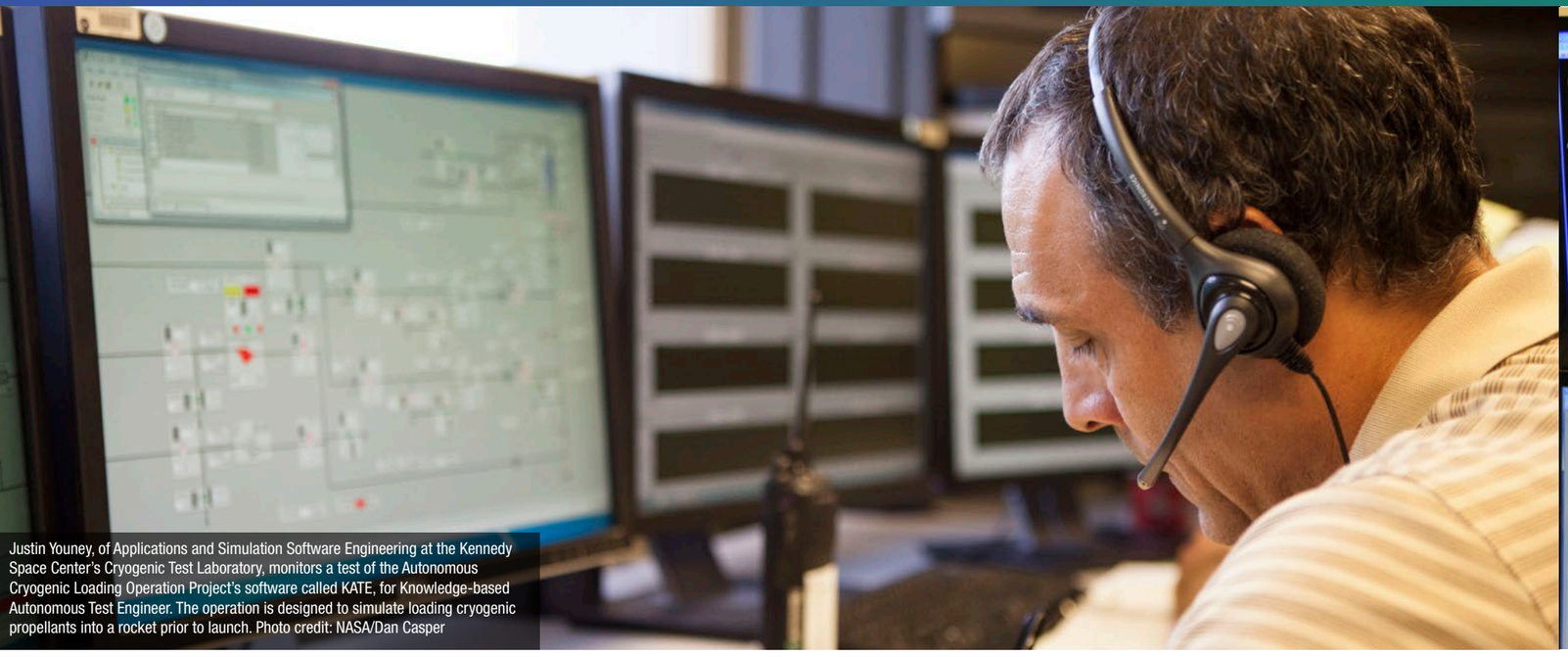
Imagine it's 2018. A rocket stands ready for a flight on a deep-space mission. Shortly after loading of liquid oxygen propellant begins, engineers monitoring the process receive an indication of a valve stuck in an open position when it should be closed. An autonomous system checks the valve's sensors, determining that it is, in fact, closed. Assurance that it was only an instrumentation problem averted a costly postponement.

Designed to do just that and much more is the Autonomous Cryogenic Loading Operations (ACLO) Project's Knowledge-based Autonomous Test Engineer (KATE). It recently was assessed by engineers at Kennedy Space Center who hope soon to implement the innovation.

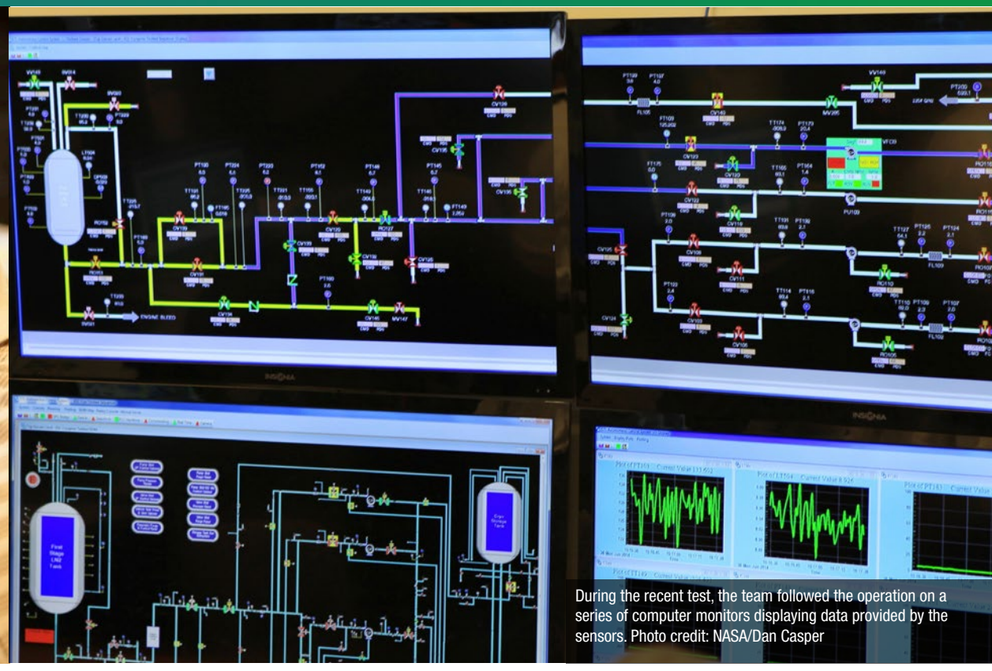
The operation took place at the spaceport's Cryogenics Test Laboratory using the Integrated Ground Operations Development Unit (IGODU). This test bed serves as a facility for developing and checking out cryogenic technologies and concepts for future ground propellant loading and servicing operations.

While cryogenic propellants have been used throughout the history of the space program, they involve many challenges. The super-cold elements have temperatures of less than 238 degrees below zero Fahrenheit.

The Integrated Ground Operations Demonstration Unit at the Kennedy Space Center's Cryogenic Test Laboratory is designed to simulate a small-scale propellant loading system at a typical launch pad. It includes a 6,000-gallon propellant storage tank (white tank on the right), a pumping complex, control valve skids and a 2,000-gallon container simulating a rocket propellant tank (black tank on the left). Photo credit: NASA/Dan Casper



Justin Youney, of Applications and Simulation Software Engineering at the Kennedy Space Center's Cryogenic Test Laboratory, monitors a test of the Autonomous Cryogenic Loading Operation Project's software called KATE, for Knowledge-based Autonomous Test Engineer. The operation is designed to simulate loading cryogenic propellants into a rocket prior to launch. Photo credit: NASA/Dan Casper



During the recent test, the team followed the operation on a series of computer monitors displaying data provided by the sensors. Photo credit: NASA/Dan Casper

The space shuttle's main engines used liquid oxygen and liquid hydrogen that were pumped from the launch pads' ground storage units into the external fuel tank.

"During the Space Shuttle Program, it took many people to operate and maintain the cryogenic loading system," said Barbara Brown, a project manager in NASA's Engineering and Technology Directorate, who is the principal investigator for the ACLO Project. "We're hoping to implement an automated and autonomous inspection system that will help us quickly isolate and resolve problems that may come up in the future."

Although funded from different sources, the ACLO and IGODU projects are complementary. They have the common goal of maturing an autonomous control capability and validating the concepts using cryogenic loading systems that monitor a propellant loading system's health and performance. The ACLO Project also is designed to aid in developing autonomous control capability for control of crucial, complex systems with less human oversight.

ACLO is a project of the Space Technology Mission Directorate (STMD) under NASA's Game Changing Development (GCD) Program. STMD is responsible for developing new tools and capabilities needed by NASA to achieve its current and future mission goals. STMD does that by rapidly developing and demonstrating revolutionary, high-payoff technologies through collaborative partnerships. The result of these investments enables NASA to support a broad array of future missions and make a difference in the world around us with spin-off innovations.

IGODU is part of the agency's Advanced Exploration Systems (AES) program. AES is pioneering new approaches for rapidly developing prototype systems, demonstrating key capabilities and validating operational concepts for future human missions beyond Earth orbit.

Brown noted that the recent demonstration of ACLO met the first milestone under the GCD Program. Additionally, the Ground Systems Development and Operations Program at Kennedy now has agreed to evaluate the capability.

"ACLO and IGODU are sharing in the development of the autonomous control capability for propellant loading, leveraging resources and integrating components to help develop these new technologies," she said.

Cryogenic propellant loading operations for the shuttle typically involved several large groups of engineers and managers monitoring the propellant ground and flight systems during the crucial final hours prior to launch. The hazardous nature, complexity and vulnerability of the launch vehicle, as well as associated ground servicing systems, combined to drive the size of this workforce on launch day. The experts made decisions about the ability to continue safe operations, recover from system faults or failures, and whether to postpone the operation.

"Our goal is to reduce the number of people required to control crucial, complex systems," Brown said. "In addition, we need to ensure new capabilities safely and efficiently load propellants on future launch vehicles such as the Space Launch System."

A powerful new launch vehicle, the Space Launch System (SLS), will take astronauts farther into space than ever before using NASA's Orion spacecraft, providing a new capability for human exploration beyond low-Earth orbit.

The autonomous cryogenic loading capability and component technologies developed under the ACLO Project also will be used to help improve concepts for variable levels of self-sufficiency. This will help NASA rapidly adapt to and support various launch concepts with different types of rockets at a single launch pad.

During the recent assessment, engineers and scientists at Kennedy's Cryogenic Test Laboratory preformed a test of the ACLO's autonomous control software using KATE. The operation was designed to simulate loading cryogenic propellants into a rocket prior to launch and find any technology gaps in the software.

Robert Johnson, of the Research and Technology Management Office in Kennedy's Center Planning and Development Directorate, manages the IGODU project and is working with Brown in managing the joint projects. He noted that the IGODU test bed is set up just outside the Cryogenic Test Lab's control room. Two large cylindrical storage tanks are connected by a series of highly instrumented pipes. The setup was designed to simulate a ground storage vessel from which to load cryogenic propellant into a rocket fuel tank.

"It consists of a small scale propellant loading system that mimics the cryogenic propellant servicing system at a typical launch pad," he said. "It includes a 6,000-gallon propellant storage tank, a pumping complex, control valve skids and a 2,000-gallon container simulating a rocket propellant tank."

The Simulated Propellant Loading System (SPLS) at the Cryogenic Test Bed Laboratory provides an environment for testing advanced cryogenic components, sensors and health management technologies.

Johnson explained that it also allows demonstration of a control system capable of recognizing and automatically correcting simple system failures typical of launch vehicle servicing systems. The connecting pipelines include valves and sensors similar to what would be used at a launch pad.

"For this test we used liquid nitrogen," he said. "We had a series of valves and over 150 sensors along the pipes, to provide data on temperature, pressure and flow rates."

Autonomous controls can independently attempt to overcome instrumentation failures by bypassing failed sensors and components or redefining control points. The automation of functions and processes within the system is designed to provide repeatable, reliable loading operations that need only minimal human oversight and intervention.

During the recent test, the team followed the operation on a series of computer monitors displaying data provided by the sensors. As hardware failures occurred during the SPLS operation, the KATE system determined if a failure indication was actually a hardware fault or an instrumentation failure and issued advisory recommendations to those monitoring the test to continue the operation.

"This was during the interactive control mode," Brown said. "During autonomous control mode, KATE actually performed the diagnosis and autonomously issued the recovery steps."

Charlie Goodrich, an engineer with Technik Inc. who was supporting the cryogenic loading test, noted that a launch-day scrub can cost millions of dollars.

"A system that helps us determine that it's just instrumentation and not a real fault would make us more efficient and be more cost-effective," he said.

The Autonomous Cryogenic Loading Operations Project's Knowledge-based Autonomous Test Engineer (KATE) recently was assessed by engineers at Kennedy Space Center. The operation took place at the spaceport's Cryogenics Test Laboratory using the Integrated Ground Operations Development Unit. Photo credit: NASA/Dan Casper

Technik provides management systems engineering services, software development, project management and other support functions for the agency's Information Technology and Communications Services Directorate at Kennedy.

Brown began working on the concept for Autonomous Cryogenic Loading Operations in 1988.

"We developed and tested it for the Space Shuttle Program using the liquid oxygen system, but it was never deployed as one of the Firing Room monitoring applications," she said. "As we're now working to transition to an affordable, multi-user spaceport, we need to refocus on cost-effective ways of doing business."

Brown explained that when the KATE system is implemented, it could provide health and status only or it could autonomously control the cryogenic propellant loading operations under nominal and off-nominal conditions. In either situation, it would identify anomalies, isolate component failures and safely continue operations in degraded conditions or recover system function.

"We hope to provide repeatable, reliable autonomous loading operations and reduce the heavy reliance on a large group of people being available to operate and maintain ground systems and to conduct launch operations," she said. "Ultimately, we want to reduce the workload on human operators and lower the cost of operations and maintenance."

The next portion of the project being considered for development is a robotic unit capable of inspections and repairs.

"The mobile platform, or Advanced Inspection System (AIS), would provide an automated inspection and repair capability," Brown said. "Complete with a camera, sensors and tools, the unit could venture into areas that would be too hazardous for humans."

The mobile inspection capability could assist operators during propellant loading. Looking like a toolbox on wheels, the device will have a television camera and mechanical arm for conducting repair tasks. Both KATE software and AIS will be further demonstrated during the execution of the Advanced Propellant Loading System Project managed by Johnson.

In the future, Brown believes the technologies will provide viable options for executing a countdown for future launch vehicles.

"We're pleased with the progress so far," Brown said. "Hopefully, this will help NASA achieve its cost goals as we explore beyond Earth." SpM

BAMBI BUCKET

Crews tackle fires using local bodies of water, helicopter

BY BOB GRANATH

Wildfires are in the news almost every day. Firefighters respond with teams on the ground and in the air. The most up-to-date tools include helicopters and aircraft that drop large quantities of water and flame retardants. This technology also is available at Kennedy Space Center. Aircraft Operations teams are training to perfect the skills needed to ensure they are ready to use these tools in the event of an out-of-control blaze at the spaceport.

Mike Tillema, chief of Flight Operations in the Operations Support Division of NASA Center Operations, center, discusses plans for a training session to practice use of a Bambi Bucket in honing firefighting techniques Sept. 25. Bill Martin, a URS Federal Technical Services pilot in NASA Flight Operations, is on the left with crew chief Mark Smith, also of URS. Photo credit: NASA/Frankie Martin

A three-person helicopter crew recently practiced picking up water from a nearby waterway and dropping it on simulated targets at the center's Shuttle Landing Facility.

Bill Martin, a URS Federal Technical Services instructor pilot in NASA Aircraft Operations, explains that the operation includes using a device known as a "Bambi Bucket," attached by a 23-foot cable to one of NASA's three UH-1H "Huey" helicopters.

"Pilots can lower the bucket into one of the nearby lagoons or canals and pick up as much as 324 gallons of water," he said. "The water can then be dropped, as needed."

The four-foot-tall Bambi Bucket was developed in 1982 by SEI Industries Ltd. of Delta, British Columbia, in Canada. It is a collapsible bucket using a pilot-controlled valve that can deliver a concentrated column of water from the helicopter to the fire. According to the company's website, the Bambi Bucket is now widely used by forest and land management agencies in more than 110 countries.

"The bucket is designed to help us contain a fire, not necessarily to put it out," Martin said. "If firefighters on the ground become surrounded by flames, we can come in at low level and drop water on a specific spot to open an escape route for the people on the ground."

Opposite: Securely strapped to the helicopter floor, crew chief Mark Smith of URS looks out the side door down at the Bambi Bucket on Sept. 25. This allows him to tell the pilot precisely when to release the water over the target.
Photo credit: NASA/Frankie Martin

When temperatures soared above 100 degrees for several days during the summer of 1998, wildfires in Central Florida forced tens of thousands of residents to evacuate and dozens of homes were destroyed. At the same time, several brush fires occurred at Kennedy. While no serious damage was done, this event showed the need for more advanced equipment for the center's firefighters.

The Bambi Bucket was obtained in 2000 and has played a role in helping fight brush fires and ensuring center safety.

On Jan. 31, 2012, a prescribed burn was taking place in the Kennedy Industrial Area. During the burn, the forecast winds changed unexpectedly, resulting in smoke and flames moving in undesired areas. NASA Flight Operations was called on to use two of the agency's helicopters equipped with a Bambi Bucket to extinguish a fire near a building to help prevent the structure from catching fire.

Over a period of time, dried material can collect in wooded areas. Prescribed burns are

When needing to spread water in a straight line, a “Stitch Drop” is used as the helicopter flies in a direct path over a fire Sept. 25. This and similar training runs are designed to make sure crews are ready to support a firefighting emergency if needed. Photo credit: NASA/Frankie Martin

conducted to reduce the amount of brush in a designated area and to minimize the likelihood of an out-of-control wildfire that could be caused by a lighting strike or other spark. The prescribed burns also are needed to protect and restore wildlife habitat.

There are several ways water can be dropped on a specific target, depending on the need.

The “Wet Drop” requires the helicopter crew to come in and hover, dropping water to wet down an area or a building to prevent the spread of a fire.

A “Spot Drop” is similar, except the crew hovers at a lower altitude, resulting in the water hitting a small area, aiming to put out the blaze in a specific location.

When spreading water in a straight line is needed, a “Stitch Drop” is used as the helicopter flies in a direct path over a fire.

A “Hook Drop” involves the helicopter flying in an arc and releasing the water in a curved pattern.

“Our training is to practice all four types of drops,” said Martin. “We want to see if any problems come up, practice drop accuracy and keep safety as our No. 1 priority.”

For the training, a crew of three flies over traffic cones set up as targets on the south end of the Shuttle Landing Facility (SLF) runway.

During the exercise on Sept. 25, Martin was the instructor pilot and Mike Tillema, Kennedy’s chief of Aircraft Operations from the Center Operations Directorate, the pilot. Crew chief Mark Smith of URS was strapped to the helicopter floor with special harnesses. Looking out the side door down at the Bambi Bucket, he informed the pilot precisely when to release the water over the target.

“Looking out the side door provides a totally different viewpoint,” Smith said. “Basically, I’m calling the shots reporting to the pilots, providing input such as obstacles that may get in the way. The pilot has his hands full flying and we want to keep everybody safe.”

For the recent training, the helicopter crew hovered over one of the canals surrounding the SLF runway and lowered the Bambi Bucket into the water.

“I give the pilots information on pulling the bucket out of the water since they can’t see it,” Smith said. “This helps him bring the bucket straight up and avoid getting it snagged.”

After ascending, the crew circled around heading south to north and flew a “Stitch Drop” over the line of traffic cones as targets. Splashing the row of “bull’s eyes,” the water mowed down the cones like dominoes.

So it went, one practice run after another, each time hitting the targets, perfecting their skills for a time when life or property may be at stake.

Training also involves teams on the ground. Like Martin, Kurt Giacomelli, the Aviation Safety officer with URS, wants to keep everyone focused on the center’s safety culture.

“In an emergency situation where the goal is to fight a fire, we don’t want to get caught up in the moment,” he said. “We always want to stay focused on safety for the flight crew and everyone on the ground involved in the mission.”

During a real fire emergency, Giacomelli closely manages activities with the entire team involved. This includes coordinating activities between Aircraft Operations and firefighters on the ground.

“It takes time and effort to execute the preparations and support for an air operation to go smoothly,” he said, “from tabletop review, preflight activities, mission support, mission operation and post flight.”

According to Giacomelli, the training helps everyone to become familiar with their roles and responsibilities so it will be easier in a real time emergency.

“That’s why pilots who will be flying together, train together,” he said. “Our main goal is to enhance safety while improving our process in training, support and mission success.”

After the training runs at the SLF, Tillema noted that gaining a feel for the way the Bambi Bucket system works is a key element of the training.

“All went well,” he said, “but you really feel the difference when you lift that bucket out of the water. We come straight up to avoid having the bucket swinging under us. We’re now carrying an additional 2,000 pounds and the flight characteristics change with that weight.”

Tillema had high praise for the team participating in the exercise.

“This was some of the best training I’ve witnessed,” he said. “All procedures were pre-briefed, flown and then reviewed with safety first and foremost in all of our minds. Bill Martin and Kurt Giacomelli did a great job setting this event up. This will definitely help us be ready for a real-world event.”

Being familiar with how things work and the challenges involved is why Martin believes practice is crucial.

“This training is designed to make sure we are available to provide support in a firefighting emergency,” he said. “Then we are more prepared for a dynamic situation that may occur when flying over an actual fire.” SpM

SUPER COOL TECHNOLOGY

Several Lead Zirconate Titanate (PZT) mass gaging sensors were attached to a composite tank Aug. 25 inside a laboratory at the Cryogenics Testbed Facility at Kennedy Space Center. Photo credit: NASA/Daniel Casper

Mass gaging system will measure fuel transfer in zero gravity

BY LINDA HERRIDGE

Transfer of super-cooled or cryogenic fuel from one tank to another in the zero gravity of space may one day be a reality. But the challenges of measuring fuels and fuel levels in the weightlessness of space must be solved first.

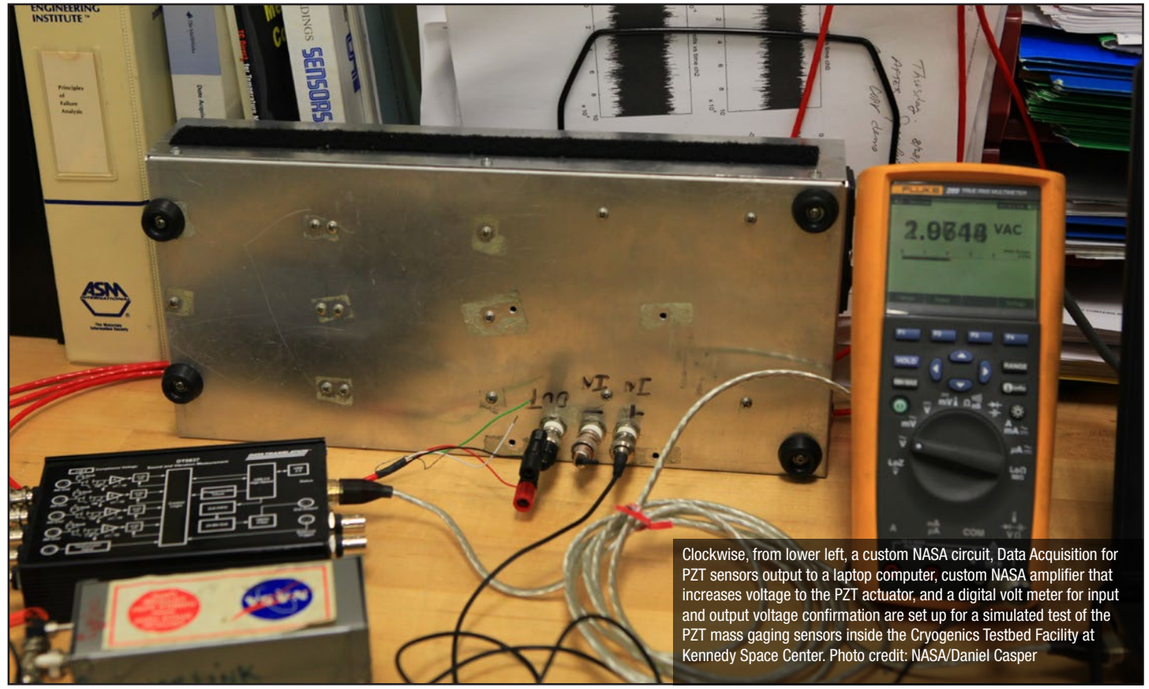
Rudy Werlink, a fluid systems engineer in the Fluids Test and Technology Development Branch at Kennedy Space Center, has developed a sensor technology that will be tested on the early suborbital flights of Virgin Galactic's SpaceShipTwo in 2015.

From 1999 to 2005, Werlink worked at Langley Research Center in Hampton, Virginia, where he focused on the Lead Zirconate Titanate (PZT) sensors, which incorporated NASA Langley patents and created the PZT-based system to determine component vibrational signatures for health monitoring and mass/volume measurements on tanks. The technology was patented at Langley in 1999 and licensed to a company in Sarasota, Florida, in 2000.

The PZT Mass Gaging technology is a type of sensor that measures the frequency of mass vibration to detect mass and fluid levels. Researchers will use PZT sensors attached to two tanks for a fluid transfer experiment during zero gravity conditions on SpaceShiptTwo flights. The flight testing of the sensors will support on-orbit propellant storage stability technology development work being done by Embry-Riddle Aeronautical University, in Daytona Beach, Florida, and Carthage College in Kenosha, Wisconsin.

Both tanks will slowly rotate or spin, as water from one full tank is transferred to the second tank, during five minutes of exposure to zero gravity on the flight. Rotating the tanks makes the water collect in the bottom.

The PZT sensors attached to the outside wall of the supply tank will be used to detect the amount of water remaining.



Clockwise, from lower left, a custom NASA circuit, Data Acquisition for PZT sensors output to a laptop computer, custom NASA amplifier that increases voltage to the PZT actuator, and a digital volt meter for input and output voltage confirmation are set up for a simulated test of the PZT mass gaging sensors inside the Cryogenics Testbed Facility at Kennedy Space Center. Photo credit: NASA/Daniel Casper

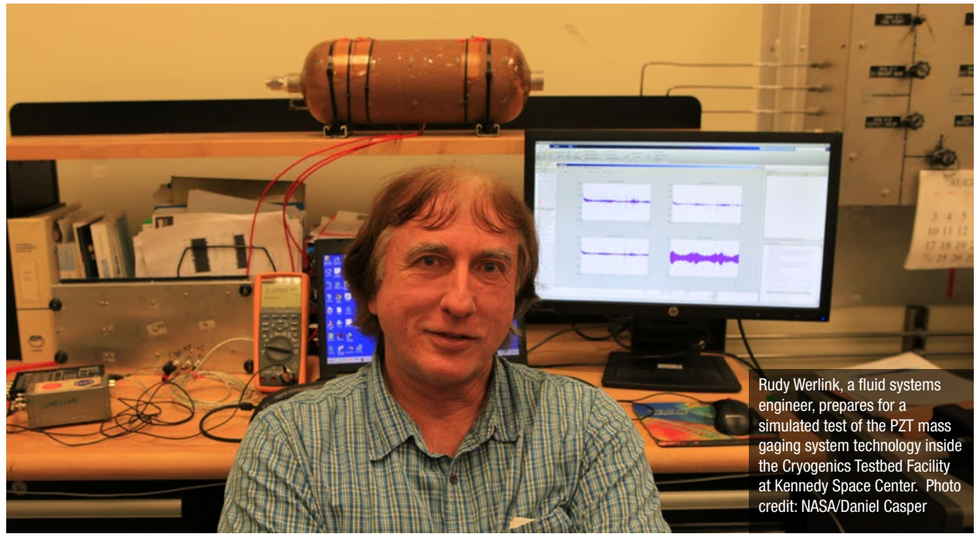
The sensors also could be used to detect the tank's rigidity or stiffness, and if there are any defects.

"To go beyond low-Earth orbit, we need to develop much greater payload capacity by lowering tank weights and deploying a fuel transfer depot," Werlink said. "This technology could provide key solutions to these engineering challenges.

Previously, the technology was tested on the Zero G commercial aircraft parabolic flights in 2010 through a Systems Engineering Education Development Program with Carthage College, with flights repeated in 2011 and 2012. Water in one tank was transferred into another tank using a pump with the PZT system data indicating water quantities in the tanks under microgravity conditions.

The University of Florida in Gainesville also will test the PZT technology on future SpaceShipTwo flights as part of their space technology experiments to demonstrate volume measurement and status in zero gravity of cryogenic-filled tanks on the space station and other flight vehicles

The SpaceShipTwo suborbital technology demonstration flights are sponsored by NASA's Space Technology Mission Directorate's Flight Opportunities program. NASA's Flight Opportunities Program provides suborbital flight



Rudy Werlink, a fluid systems engineer, prepares for a simulated test of the PZT mass gaging system technology inside the Cryogenics Testbed Facility at Kennedy Space Center. Photo credit: NASA/Daniel Casper

testing of new space technologies before they're flown in the harsh environment of space.

Werlink currently is working to patent the health monitoring and mass gaging PZT system. The electronics and communications will be packed into one practical in-situ system.

Werlink moved to Florida in the 1960s and grew up in Orlando. He watched the Apollo 11 moon landing and immediately became interested in science and space.

He came to Kennedy in 1980 and worked for USBI on the space shuttles and the hydraulic control system for the solid rocket boosters (SRBs). In 1985, he worked at Marshall Space Flight Center in Huntsville, Alabama, where he helped design the thrust vector controls for the SRBs.

He returned to Kennedy in 1989 and worked in the Special Projects Branch of Design Engineering. Projects included two-phase flow measurements, space shuttle liquid oxygen fill and launch, and orbiter brake vibration analysis.

After his time at Langley, he returned permanently to Kennedy and the Cryogenic Test Laboratory in 2005 and continued his work on the PZT sensor technology.

"The sky's the limit," Werlink said. "We will eventually prove transfer of cryogenics in space for long-term spaceflight, whether it's to an asteroid or Mars." SpM

APOLLO XII The Pinpoint Mission

Encore of lunar visit inspires first precision extraterrestrial landing

BY BOB GRANATH

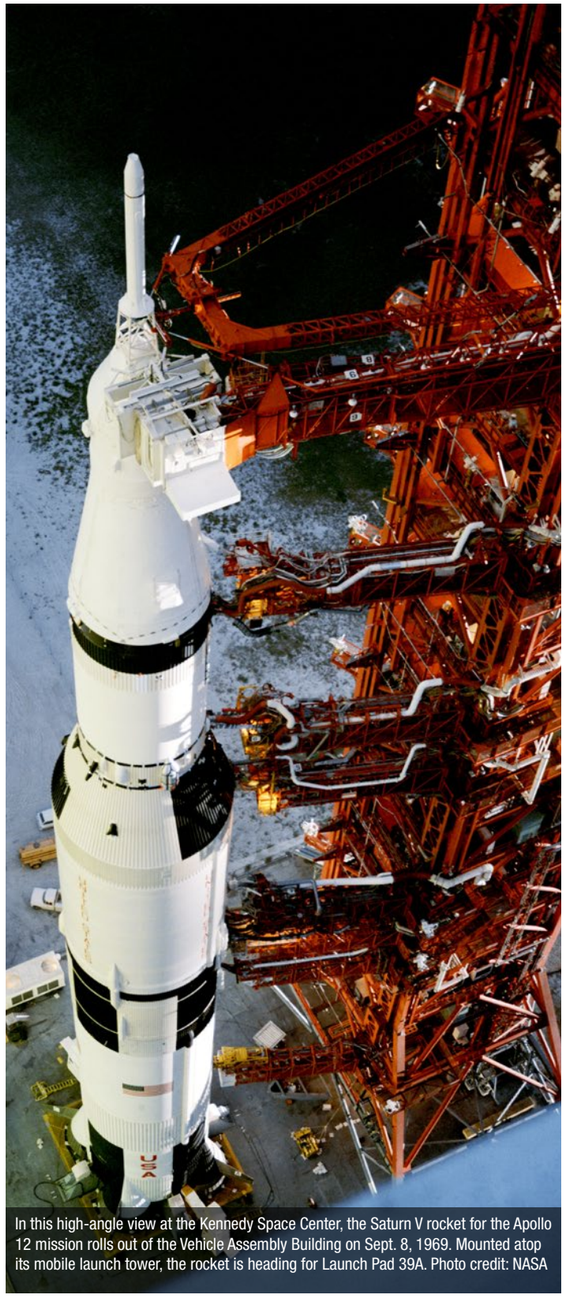
In an address to Congress in 1961, President John F. Kennedy challenged the nation to “land a man on the moon and return him safely to Earth” before the end of the decade. With the flight of Apollo 12, 45 years ago this month, NASA achieved that goal a second time.

The crew of commander Charles “Pete” Conrad, command module pilot Richard Gordon and lunar module pilot Alan Bean were all U.S. Navy officers. Their training included simulations at Kennedy Space Center. They practiced a pinpoint landing within walking distance of the robotic Surveyor 3 spacecraft that touched down on the slope of a shallow crater in the moon’s Ocean of Storms region on April 20, 1967.

After months of processing in Kennedy’s Vehicle Assembly Building, Apollo 12’s Saturn V rocket rolled to Launch Pad 39A on Sept. 8, 1969. Liftoff took place during a rain shower on Nov. 14, 1969. At 36 seconds into the flight, the vehicle triggered a lightning discharge. All three fuel cells briefly went offline, along with much of the command/service module instrumentation. The quick action by Electrical, Environmental and Consumables manager John Aaron in Mission Control and by the crew allowed the vehicle to continue flying without further problems.

On the mission’s fifth day, Gordon remained in the command module, named Yankee Clipper, while Conrad and Bean descended to the moon’s surface aboard the lunar module, Intrepid. Bean began looking for landmarks and quickly noted they were right on target.

The Apollo 12 crew poses in front of a full-scale mockup of a lunar module. From the left are commander Charles “Pete” Conrad Jr., command module pilot Richard Gordon Jr., and lunar module pilot Alan Bean. Photo credit: NASA



In this high-angle view at the Kennedy Space Center, the Saturn V rocket for the Apollo 12 mission rolls out of the Vehicle Assembly Building on Sept. 8, 1969. Mounted atop its mobile launch tower, the rocket is heading for Launch Pad 39A. Photo credit: NASA

“Hey! Look at that crater,” he said, “right where it’s supposed to be!”

As Intrepid neared touchdown, Conrad noted at about 35 feet, the exhaust from the lunar module began kicking up the regolith on the surface. It appeared to be more that that experienced by fellow astronaut Neil Armstrong, commander of the first lunar landing four months earlier.

“I think we’re in a place that’s a lot dustier than Neil’s,” he said. “It’s a good thing we had a simulation, because that was an IFR (instrument flight rules) landing.”

Instrument flight rules include regulations established to govern flight under conditions in which visual references are not possible. During a post-flight debriefing, Conrad explained that the dust was worse than expected.

“At that point, the dust was bad and I had absolutely no attitude reference by looking at the horizon (out the window).”

Using the lessons of the Apollo era and robotic missions to Mars, NASA scientists and engineers at Kennedy are studying how to avoid such hazards in future extraterrestrial landings.

Minutes after the lunar touchdown, Conrad and Bean received a message from overhead.

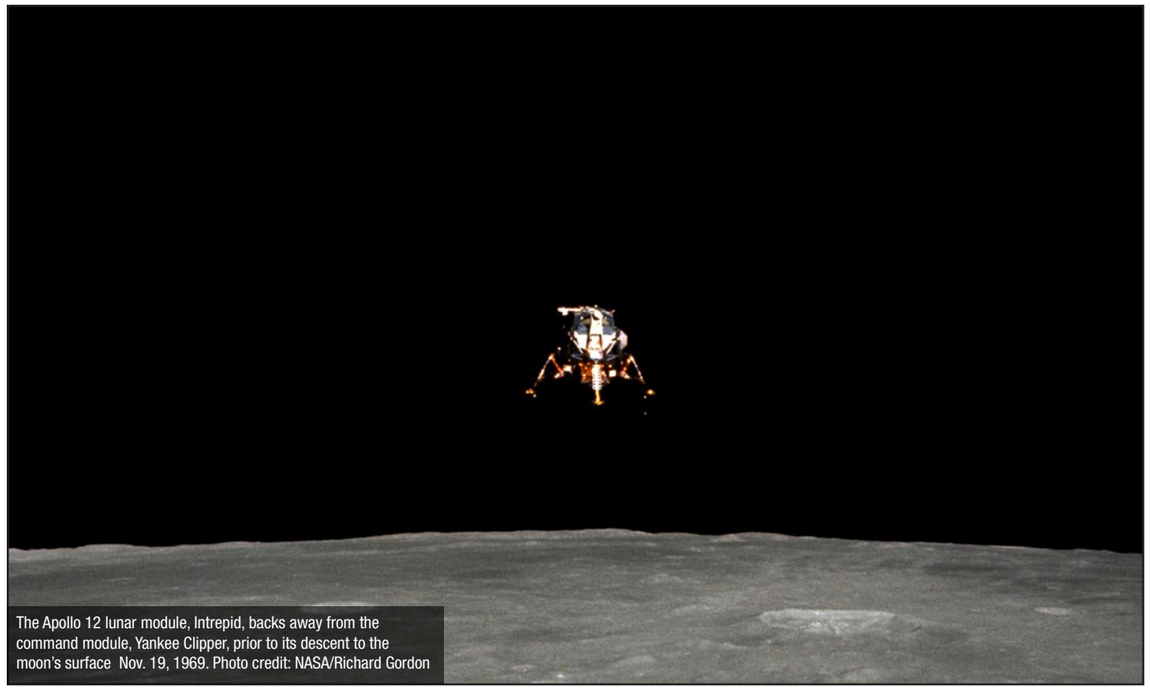
“Intrepid,” Gordon said, “congratulations from Yankee Clipper!”

The first moonwalk began a few hours later with Conrad descending the lunar module’s ladder and making note of Armstrong’s iconic words as he first stepped onto the moon four months earlier.

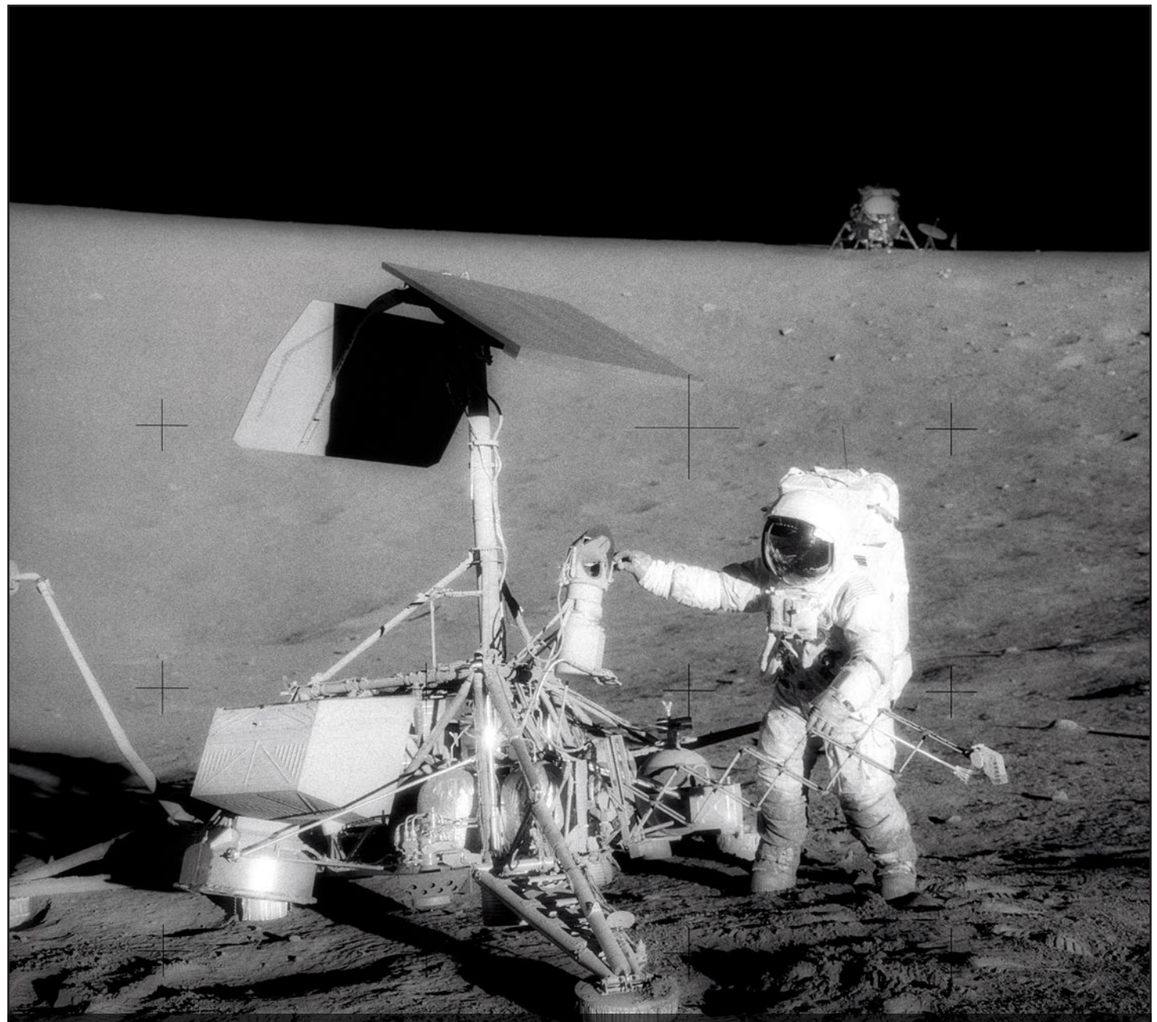
“Whoopee,” Conrad said, “Man, that may have been a small one for Neil, but that’s a long one for me.”

He then looked behind Intrepid to see if they had, indeed, succeeded in landing near Surveyor 3.

“Guess what I see sitting on the side of the crater,” Conrad said. “The old Surveyor. It can’t be any farther than 600 feet from here. How about that?”



The Apollo 12 lunar module, Intrepid, backs away from the command module, Yankee Clipper, prior to its descent to the moon’s surface Nov. 19, 1969. Photo credit: NASA/Richard Gordon



In history’s first attempt at precisely landing humans on another celestial world, the Apollo 12 lunar module, on the rim of a crater in the background, landed a scant 538 feet from the Surveyor 3. Apollo 12 commander Pete Conrad is seen checking out the robotic probe’s television camera. The television camera and several other pieces were taken from Surveyor 3 and brought back to Earth for scientific examination. Surveyor 3 soft-landed in the moon’s Ocean of Storms region on April 19, 1967. Photo credit: NASA/Alan Bean

In history’s first attempt at precisely landing humans on another celestial world, Conrad nailed it. Images taken in 2011 by NASA’s Lunar Reconnaissance Orbiter indicated Intrepid landed a scant 538 feet from the Surveyor.

The primary mission of the first moonwalk, which lasted three hours and 56 minutes, was to set up the Apollo Lunar Surface Experiments Package, or ALSEP, which was left on the moon’s surface to gather seismic and other scientific data. Seismic readings of moonquakes would tell scientists much about the makeup below the lunar surface. Conrad and Bean also collected rock and soil samples.

When checking the Surveyor 3 during their second moonwalk, they first believed its white color had been changed by exposure to the sun. However, upon further examination, they realized

Apollo 12 commander Pete Conrad backs out of the lunar module's hatch as he prepares to descend the ladder to become the third human to walk on the Moon. Photo credit: NASA/Alan Bean

it was covered by lunar dust.

"We thought this thing had changed color, but I think it's just dust," Bean said. "We rubbed into (Surveyor's) battery, and it's good and shiny again."

During Intrepid's landing, the descent engine blew lunar dust onto the probe. The spacecraft was covered by a thin layer of dust giving it a tan hue.

Conrad and Bean removed Surveyor's television camera and other parts for examination and study to learn how materials respond to years of exposure on the moon.

Following three hours and 49 minutes on the surface, the explorers returned to the lunar module with parts from Surveyor and additional geological samples.

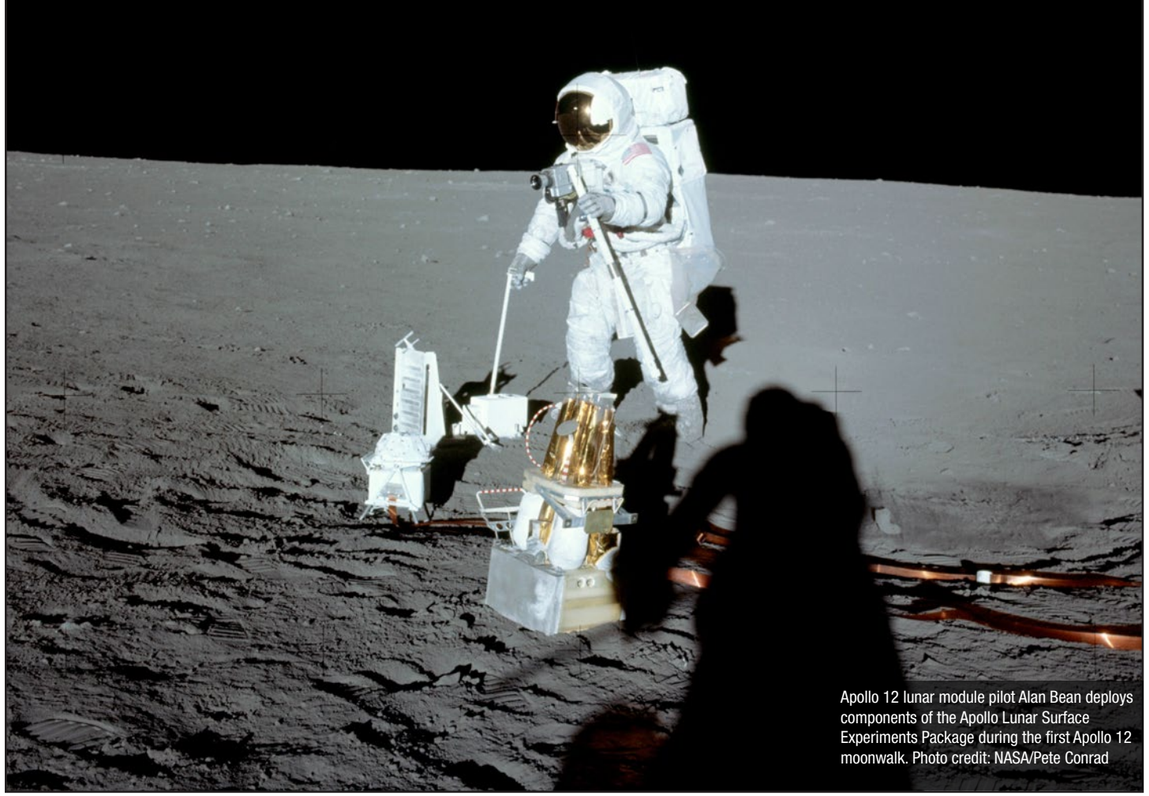
Once all the material collected on the moon was secure, Conrad and Bean began preparing for the lunar liftoff, completing 31.5 hours on the moon.

After the rendezvous with Gordon aboard the command module, the lunar collections were transferred to Yankee Clipper. Intrepid's ascent stage was later dropped back to the moon's surface for an early test of the ALSEP experiments they left behind. Scientists reported that the seismometers registered the vibrations for more than an hour.

The crew remained in lunar orbit an additional day taking photographs. On the return trip to Earth, the crew also photographed a solar eclipse. However this one was of the Earth eclipsing the sun.

Yankee Clipper splashed down in the Pacific Ocean on Nov. 24, 1969, and was recovered by the aircraft carrier USS Hornet.

One of the primary achievements of the second lunar landing was an exercise in pinpoint targeting. Apollo 12 succeeded in landing at its intended objective, perfecting a skill that would prove crucial for upcoming Apollo missions. Precision landings in future Apollo missions would foster exploration in regions where the lunar surface is fraught with landscapes including obstacles such as mountains and canyon-like rills. These sites provided some of the most geologically valuable findings, unlocking secrets to better understand both the moon and planet Earth. SpM



Apollo 12 lunar module pilot Alan Bean deploys components of the Apollo Lunar Surface Experiments Package during the first Apollo 12 moonwalk. Photo credit: NASA/Pete Conrad

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