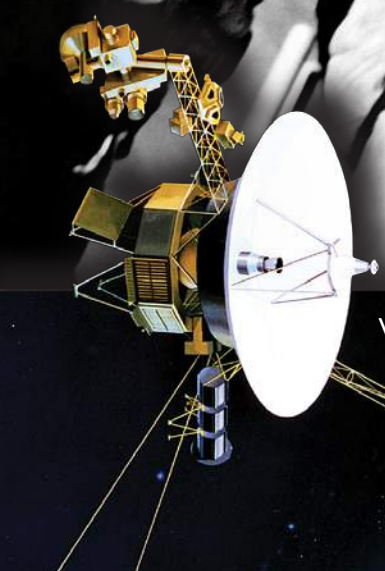
ROCKET STEM

Volume 1 • Number 1 • January 2013

Exploring Space
= Science
+ Technology
+ Engineering
+ Mathematics
Plus **YOU!**

Last Men On The Moon



Voyager Journeys Into Unknown

Working Inside Mission Control

Curiosity Exploring Mars

Photos: NASA

"There is no strife, no prejudice, no national conflict in outer space as yet. Its hazards are hostile to us all. Its conquest deserves the best of all mankind, and its opportunity for peaceful cooperation may never come again. But why, some say, the moon? Why choose this as our goal? And they may well ask why climb the highest mountain? Why, 35 years ago, fly the Atlantic? Why does Rice play Texas?

"We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too."

– President John F. Kennedy. September 12, 1962. at Rice University. Houston. Texas

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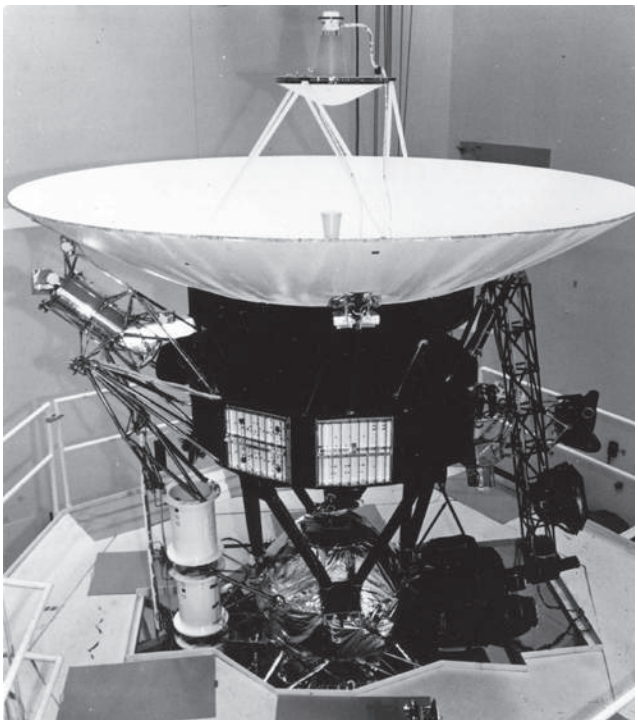
Never endi

Voyager spacecraft still making discoveries as they near boundary of our solar system

By Mike Killian

For more than thirty years, a pair of twin NASA spacecraft have been on an epic journey through the solar system. A journey that is arguably one of the greatest adventures in the history of mankind. They have travelled farther than any man-made objects ever have, and will soon leave our cosmic neighborhood and become the first man-made objects to visit interstellar space - the space between stars where our own sun has no influence.

Voyager 1 and Voyager 2 launched within weeks of each other in 1977 from Cape Canaveral Air Force Station in Florida. Their mission was to visit the giant outer planets of the solar system, a "grand tour" which took advantage of an unusual planetary alignment that happens only once every 177 years. The Voyagers would "slingshot" from planet to planet, using the gravity of one giant planet to push them towards the next planet, a technique known as a gravitational assist.



A prototype Voyager spacecraft is shown undergoing vibration tests at NASA's Jet Propulsion Laboratory. *Photo: NASA/JPL*

Their primary mission – to visit the giant outer planets – was a complete success. The Voyagers visited Jupiter, Saturn, Uranus, and Neptune - sending back to Earth valuable research data and images never before seen by human eyes in such detail. Voyager 2 is still the only spacecraft to have ever visited Uranus and Neptune.

The violent weather in the atmosphere of Jupiter, indications of an ocean beneath the cracked ice of Jupiter's moon Europa, the details of Saturn's rings, and a smoggy nitrogen atmosphere on Saturn's moon Titan - all were just a few of the many discoveries made by the twin Voyagers.

After leaving the realm of the planets, the Voyagers were given a new mission - the Voyager Interstellar Mission. They are now tasked with exploring the very edge of our known solar system, and beyond.

Although many of the science

Jupiter *(Visited by Voyager 1 and 2)*

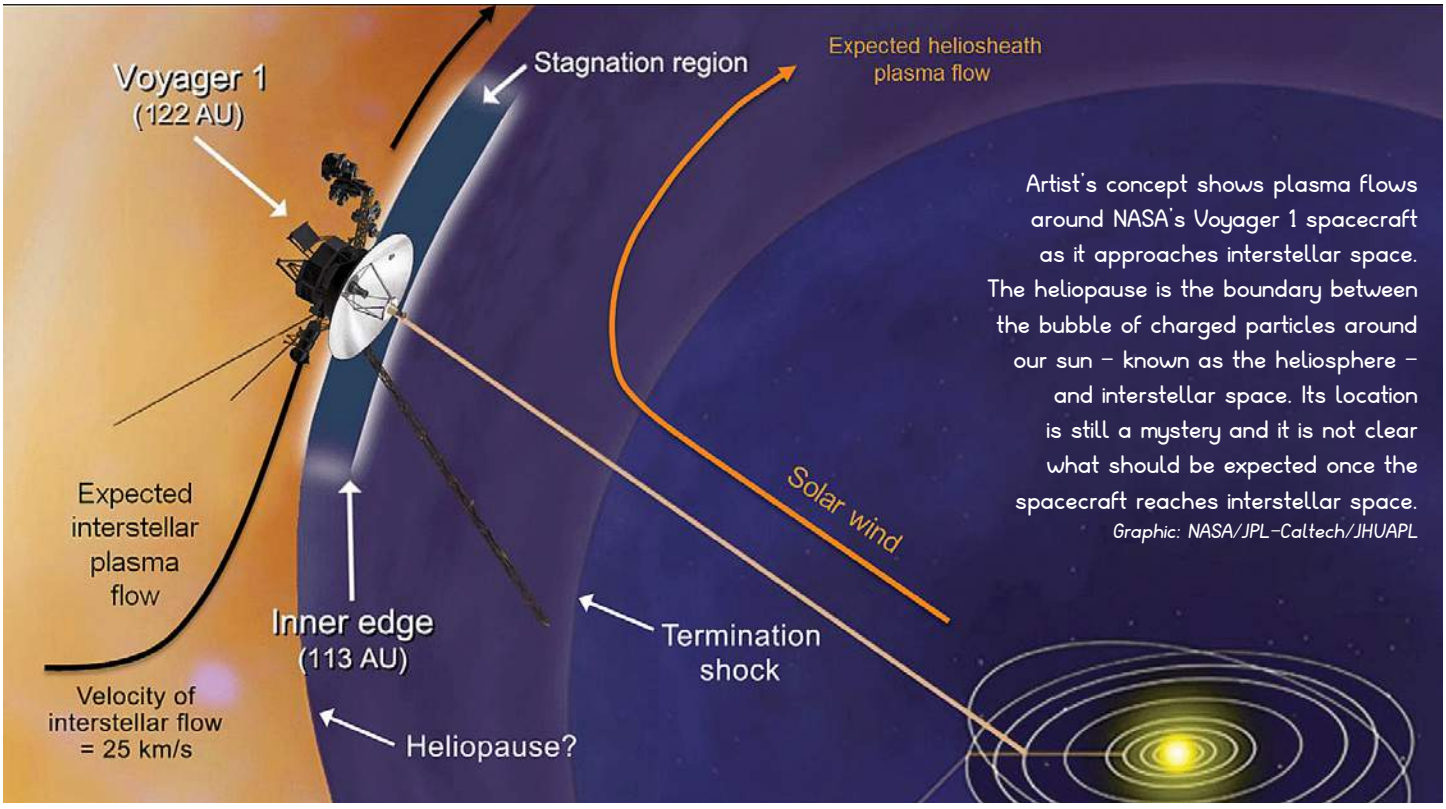

Jupiter


Callisto


Io


Red Spot

ng journey



Artist's concept shows plasma flows around NASA's Voyager 1 spacecraft as it approaches interstellar space. The heliopause is the boundary between the bubble of charged particles around our sun – known as the heliosphere – and interstellar space. Its location is still a mystery and it is not clear what should be expected once the spacecraft reaches interstellar space.
Graphic: NASA/JPL-Caltech/JHUAPL

instruments onboard both spacecraft are now dead, a handful of others are still active, and the Voyagers continue to send valuable information back to Earth - some 35 years after they left.

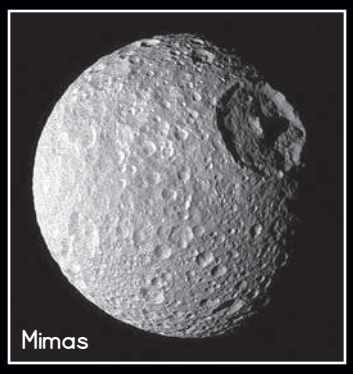
Voyager 1 has travelled the farthest, because it was launched from Earth on a different trajectory than Voyager 2. Voyager 1 is currently more than 11 billion miles away from Earth, speeding through the cosmos at over 38,000 miles-per-hour. The distance Voyager 1 has covered is so vast that astronomers do not actually measure it in miles, but in Astronomical Units, or AU. One AU is the average distance between the Earth and Sun, about 93 million miles. Voyager 1 is currently more than 123 AU from Earth, or 123 times further from Earth than Earth is from the Sun, and clearing over 3 AU every Earth year (365 days).

At these distances, radio signals from Voyager 1 take over seventeen hours to reach controllers here on Earth, and the round-trip light time from the sun is over thirty-four hours.

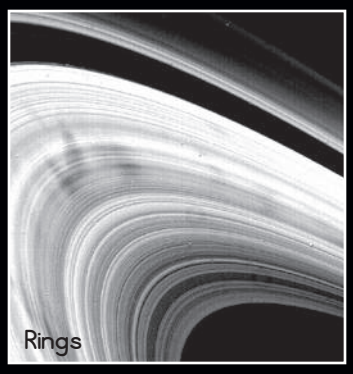
Voyager 1 crossed an area

Saturn *(Visited by Voyager 1 and 2)*


Saturn


Mimas


Dione


Rings

known as the "termination shock" and began its voyage through the heliosheath in December of 2004.

The heliosheath is the outer boundary of our solar system still dominated by the sun's magnetic field and particles contained in the solar wind.

Although astronomers don't know exactly just how wide the heliosheath is, and therefore cannot pinpoint exactly where the border between our solar system and interplanetary space is, they can see changes in the environment become more dramatic as Voyager 1 approaches the border, known as the heliopause.

In the eight years since Voyager 1 began its trek through the heliosheath, the spacecraft has encountered several dramatic changes in its space environment—all pointing to its eventual exit from our solar system into interstellar space.

Voyager 2 atop a Titan-Centaur rocket awaits launch in 1977. *Photo: NASA*

The number of cosmic rays hitting the spacecraft continues to climb, and instruments on the spacecraft detected the supersonic solar wind dropped from 150,000 mph to zero as of last spring—held back from further expansion by the interstellar wind. During the last year the spacecraft has also seen energetic particles from the solar system decline by nearly 50 percent, while the detection of high-energy electrons from interstellar space has increased 100 fold.

The most recent data from Voyager 1, which was released by NASA just last month, shows the spacecraft is now pushing through a new region at the very edge of our known solar system - a "magnetic highway" that scientists feel is the final region before crossing into deep space.

This previously unknown (and unexpected) region at the edge of our solar system is where our sun's magnetic field lines connect with the magnetic field lines of interstellar space. Particles from deep space are now streaming over Voyager 1 regularly, something that had not been seen consistently before.

The new data alone does not suggest Voyager 1 has reached interstellar space because the direction of the sun's magnetic field lines has not yet changed, but the data does show the region Voyager 1 is traveling through is rapidly changing. The influence of the sun is becoming less and less, while the influence from interstellar space is growing stronger.

Astronomers expect to see Voyager 1 leave the solar system sometime between now and 2015. When that happens big changes are expected to be seen in the data sent back to Earth. For example, energetic particles from the sun will be few and far between, and the magnetic field around Voyager 1 will change direction from that of the sun's magnetic field to that of the unexplored magnetism of interstellar space.

Although traveling slower, and thus lagging behind its cousin Voyager 1, Voyager 2 is currently traversing the solar system on a course which will eventually see it leave the solar system as well.

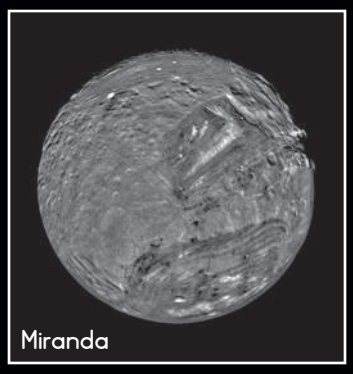
Both spacecraft are reported to be in good health, and have

DID YOU KNOW?

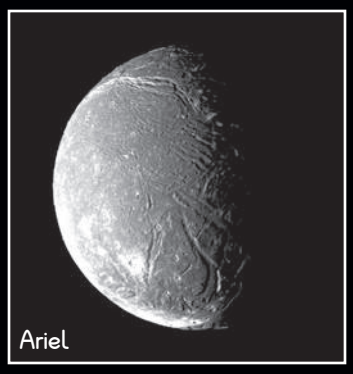
Voyager's fuel efficiency is impressive despite the launch vehicle's 700 ton weight. Voyager 2's travel distance of 4.4 billion miles to Neptune resulted in a fuel economy of 30,000 miles per gallon!

Uranus *(Visited by Voyager 2)*


Uranus


Miranda


Titania


Ariel

Jupiter and its four planet-size moons, called the Galilean satellites, were photographed in early March 1979 by Voyager 1 and assembled into this collage. They are not to scale but are in their relative positions. Startling new discoveries on the Galilean moons and the planet Jupiter made by Voyager l factored into a new mission design for Voyager 2. Reddish Io (upper left) is nearest Jupiter; then Europa (center); Ganymede and Callisto (lower right).

Photo: NASA/JPL

enough power and thruster fuel to operate until at least 2020, possibly until 2025.

The Voyagers should provide better data regarding what the space between stars and solar systems is like in a way no other spacecraft has ever been able to, simply because no spacecraft has ever actually travelled there.

When they run out of power and are no longer operable, they will continue to cruise through the cosmos indefinitely, carrying with them the famous golden record with pictures and sounds of Earth - an explanation of what Voyager is and who created it for anyone who may discover them.

Voyager 1 is not heading towards any particular star, and will not even come "close" to one for 40,000 years, when the spacecraft will pass within 1.6 light years (almost 10 trillion miles) of a star in the constellation Camelopardalis.

Voyager 2 will pass within 4.3 light years (25 trillion miles) of the brightest star in the sky, Sirius, 296,000 years from now.

Neptune *(Visited by Voyager 2)*


Neptune


Rings


Triton


Triton

Martian meteorite found rich in water

NASA-funded researchers analyzing a small meteorite that may be the first discovered from the Martian surface or crust have found it contains 10 times more water than other Martian meteorites from unknown origins.

This new class of meteorite was found in 2011 in the Sahara Desert. Designated Northwest Africa (NWA) 7034, and nicknamed "Black Beauty," it formed 2.1 billion years ago.

The meteorite's composition is different from any previously studied Martian meteorite.

"The contents of this meteorite may challenge many long held notions about Martian geology," said John Grunsfeld, associate administrator for NASA's Science Mission Directorate in Washington.

NWA 7034 is made of cemented fragments of basalt, rock that forms from rapidly cooled lava. The fragments are primarily feldspar and pyroxene, most likely from volcanic activity.

1 in 6 stars has an Earth-sized planet

The quest to determine if planets like Earth are rare or common is taking another stride forward on the journey. Using NASA's Kepler spacecraft, astronomers are beginning to find Earth-sized planets orbiting distant stars.

A new analysis of Kepler data shows that about 17 percent of stars have an Earth-sized planet in an orbit closer than Mercury. Since the Milky Way has about 100 billion stars, there should be at least 17 billion Earth-sized worlds.

Scientists have also determined that nearly all sun-like stars have planets.

Kepler is the first NASA mission capable of finding Earth-size planets orbiting in or near the habitable zone of the host star.

Ancient microbes found in Antarctic lake

In one of the most remote lakes of Antarctica, nearly 65 feet beneath the icy surface, scientists have uncovered a community of bacteria. This discovery of life existing in one of Earth's darkest, saltiest and coldest habitats is significant because it helps increase our limited knowledge of how life can sustain itself in these extreme environments on our own planet and beyond.

Lake Vida, the largest of several unique lakes found in the McMurdo Dry Valleys, contains no oxygen, is mostly frozen and possesses the highest nitrous oxide levels of any natural water body on Earth. A briny liquid, which is approximately six times saltier than seawater, percolates throughout the icy environment where the average temperature is minus 8 degrees Fahrenheit.

Despite the very cold, dark and isolated nature of the habitat, the brine harbors a surprisingly diverse and abundant variety of bacteria that survive without a current source of energy from the sun.

"This system is probably the best analog we have for possible ecosystems in the subsurface waters of Saturn's moon Enceladus and Jupiter's moon Europa," said Chris McKay, a senior scientist at NASA's Ames Research Center, Moffett Field, Calif.

Earliest galaxies seen by Hubble

Using NASA's Hubble Space Telescope, astronomers have uncovered a previously unseen population of seven primitive galaxies that formed more than 13 billion years ago, when the universe was less than 3 percent of its present age. The deepest images to date from Hubble yield the first statistically robust sample of galaxies that tells how abundant they were close to the era when galaxies first formed.

The results are from an ambitious Hubble survey of an intensively studied patch of sky known as the Ultra Deep Field (UDF) and show a smooth decline in the number of galaxies looking back in time to about 450 million years after the theorized big bang

Looking deeper into the universe also means peering further back in time. The newly discovered galaxies are seen as they looked 350 to 600 million years after the big bang. Their light is just arriving at Earth now.

A major goal of the new program was to determine how rapidly the number of galaxies increased over time in the early universe.

"There wasn't a single dramatic moment when galaxies formed. It was a gradual process," said Brant Robertson of the University of Arizona in Tucson.

Forecasts to help pilots avoid storms

A new NASA-funded prototype system developed by the National Center for Atmospheric Research (NCAR) of Boulder, Colo., now is providing weather forecasts that can help flights avoid major storms as they travel over remote regions.

The system is based on products that NCAR has developed to alert pilots and air traffic controllers about storms and related hazards, such as turbulence and lightning, over the continental United States.

"By providing pilots with a picture of where significant storms will be during an eight-hour period, the system can contribute to the safety and comfort of passengers on flights," said NCAR's Cathy Kessinger, lead researcher on the project.

Pinpointing turbulence associated with storms over the oceans is far more challenging than it is over land because geostationary satellites, unlike ground-based radar, cannot see within the clouds.

As a result, pilots often must choose between detouring hundreds of miles around potentially stormy areas or flying directly through a region that may or may not contain intense weather. Storms may be associated with hazardous windshear and icing conditions in addition to lightning, hail and potentially severe turbulence.

NASA announces new Mars rover

Building on the success of Curiosity's Red Planet landing, NASA has announced plans for a new robotic science rover set to launch in 2020.

The plan to design and build a new Mars robotic science rover with a launch in 2020 comes only months after the agency announced InSight, which will launch in 2016, bringing a total of seven NASA missions operating or being planned to study and explore our neighbor.

The future rover development and design will be based on the Mars Science Laboratory (MSL) architecture that successfully carried the Curiosity rover to the Martian surface last summer.

"The challenge to restructure the Mars Exploration Program has turned from the seven minutes of terror for the Curiosity landing to the start of seven years of innovation," NASA's associate administrator for science, and astronaut John Grunsfeld said.

Binary stars formation studied

Using computer simulations, scientists are shedding light on a question that has challenged astronomers for years: What causes wide binary stars?

Binary stars are pairs of stars that orbit each other. Wide binary stars are separated by as much as one light-year in their orbits, farther apart than some stellar nurseries are wide.

Researchers simulated the complex motions of newborn triple stars still embedded in their nascent cloud cores. They studied the motions and concluded the widest binary systems began as three stars.

Most stars are born in small, compact systems with two or more stars at the center of a cloud core. When more than two stars share a small space, they gravitationally pull on each other in a chaotic dance. The least massive star often is kicked to the outskirts of the cloud core while the remaining stars grow larger and closer by feeding on the dense gas at the center of the cloud core.

If the force of the kick is not forceful enough, the runt star will not escape, but instead begin a very wide orbit of the other two, creating a wide binary. However, sometimes astronomers find only two stars in a wide binary. This means either the star system formed differently or something happened to one of the original binary pair.

The wide binary nearest to Earth is Alpha Centauri. The star itself is a close binary. Alpha Centauri has a small companion, Proxima Centauri, which orbits at a distance of about one-quarter of a light-year.

Searching for clues to climate change

NASA is sending a remotely piloted research aircraft as high as 65,000 feet over the ocean to probe unexplored regions of the upper atmosphere for answers to how a warming climate is changing Earth.

Water vapor and ozone in the stratosphere can have a large impact on Earth's climate. The processes that drive the rise and fall of these compounds, especially water vapor, are not well understood. The Airborne Tropical Tropopause Experiment (ATTREX) will study moisture and chemical composition in the upper regions of the troposphere, the lowest layer of Earth's atmosphere.

Studies have shown even small changes in stratospheric humidity may have significant climate impacts.

Scientists hope to use the acquired data to improve global model predictions of stratospheric humidity and composition.

ATTREX is one of the first investigations in NASA's new Venture-class series of low- to moderate-cost projects.

NPP satellite reveals new composite image of Earth at night

Scientists have unveiled an unprecedented new look at our planet at night. A global composite image, constructed using cloud-free night images from a new NASA and NOAA satellite, shows the glow of natural and human-built phenomena across the planet in greater detail than ever before.

Many satellites are equipped to look at Earth during the day, when they can observe our planet fully illuminated by the sun. With a new sensor onboard the NASA-NOAA Suomi National Polar-orbiting Partnership (NPP) satellite launched last year, scientists now can observe Earth's atmosphere and surface during nighttime hours.

The new sensor, the day-night band of the Visible Infrared Imaging Radiometer Suite (VIIRS), is sensitive enough to detect the light from a single ship in the sea. VIIRS day-night band images are providing researchers with valuable data for a wide variety of previously unseen or poorly seen events.

With its night view, VIIRS is able to detect a more complete view of storms and other weather conditions, such as fog, that are difficult to discern with infrared, or thermal, sensors.

Unlike a camera that captures a picture in one exposure, the day-night band produces an image by repeatedly scanning a scene and resolving.

SALUTE *to the* *PIONEERS* *of* SPACE

By Anthony Fitch

The last man to walk on the moon decided to celebrate the 40th anniversary of this occasion at the place where his flight career started. Held Dec. 15 at the National Naval Aviation Museum, with 1,200 of his friends, the event was split up into several different panel discussions.

Gene Cernan stands with family and friends in front of the new LEM replica unveiled in December at the National Naval Aviation Museum. *Photo: Chase Clark*

The morning panel included individuals such as Apollo XIII commander James Lovell, Lunar Module Pilot Fred Haise, Flight Controller Eugene Kranz and NASA engineers Glynn Lunney and Gerry Griffin. Each discussed the many events of what went wrong during Apollo XIII and the race to get the crew back home alive. Mentioned was the often forgotten center engine early cutoff of the second stage of the Saturn V. The discussion continued on to the topic of what everyone was doing during the events of Apollo XIII, such as engineers trying to figure out the cause, astronauts testing out the solutions in the simulators, and the mission controllers working problems such as trajectory and other mission parameters.

Upon the conclusion of the morning panel guests were treated to a luncheon and panel presentation with speakers Senator John Glenn (first American to orbit Earth) and Captain Eugene Cernan (commander of Apollo XVII and last man to walk on the moon). They discussed their personal experiences in becoming astronauts, such as training at high g-force loads. There were also personal anecdotes where John Glenn mentioned that they wouldn't let him have a spacewalk during his flight on STS-95 because they were afraid he would "wander off." Also, Cernan while speaking fondly about the Saturn V called it "his mistress."

The afternoon panel discussed the events of the Mercury, Gemini and Apollo programs. This panel was hosted by greats such as Charlie Duke, Walter Cunningham, Richard Gordon, Tom Stafford, Cernan and David Scott. The panel focused mostly on the timelines and experiences from the various space programs from Mercury to Gemini to Apollo. There were several comments about the risks that were taken during the various programs, such as the tragedy of the Apollo I fire, the incidents of Apollo 10, 12, & 13, interactions with Mission Control at the Johnson Space Center in Houston, Texas, and other events during the race to the Moon.

On a closing note Cunningham mentioned that now we are "too much of a risk averse society" [in regard to the length of time it takes to design, build and fly spacecraft]. Contrasting that was Cernan who said, "Considering the tail end of Apollo was so long ago, I didn't think it would take this long, but it isn't the end. What is going on now is just the beginning."

As evening fell, a swanky reception was held to unveil a lunar lander replica now on display inside Hangar Bay 1 of the museum in Pensacola, Florida. Afterward, guests were treated to dinner while listening to stories from Cernan and other astronauts.

Photos: Chase Clark

Quotables

"One of the great legacies of Apollo is that under the right leadership, and willing regard for the future, there isn't anything we can't do."

Thomas Stafford

"Apollo 13 was a classic case of crisis management. A case where good leadership, not just at the top of the organization but throughout the organization, because leadership fostered teamwork and teamwork was the glue that put Apollo 13 back in the water."

"The news that Apollo 13 was going to fly was on the 97th page of the New York Times, under the weather."

James Lovell

"That's your identity. That's home and it's moving through space with purpose with the Moon in tow. You're in sunlight but you're surrounded by blackness, a paradox."

"I always tell young people to aim for the Moon. I tell them 'I walked on the Moon before you were born. What can you do?'"

Gene Cernan

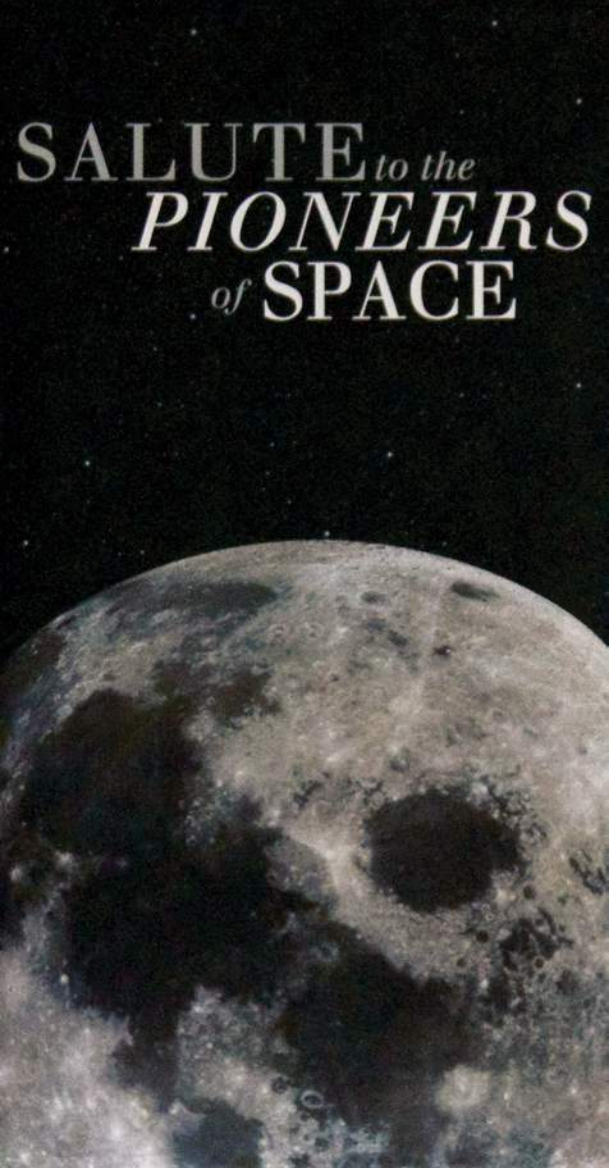
"The delay from the Apollo I fire allowed us to get many changes that were turned down due to scheduling. As a result we ended up with a spacecraft that was absolutely marvelous."

Walter Cunningham

"One of the things we were trained to do is don't give up, and just keep working the options. Thankfully on Apollo 13 we never ran out of options. But we did get close."

"The agency [NASA] was extremely nimble, in that it could move in a hurry and make decisions. It was one of our finest hours."

Gerry Griffin



"When you are up there and you look back you are looking at huge swaths of the Earth at one time. And you don't see the borders. There are no blue nations, no pink nations, no green nations, like there are on a map."

"You're going around the Earth once every one hour and 29 minutes and it's a wonderful experience. You're going faster than people have ever gone before but you can't help but look down…and wonder as people why we can't get along better on this beautiful thing we call Earth."

"Keep your curiosity. The people I've found to be the most productive are the ones with the most curiosity."

John Glenn

"The significance of my flight (Gemini XI) was charged with rendezvousing on the first orbit. Due to lunar orbits being so short it was critical we have the skills to rendezvous in a single orbit."

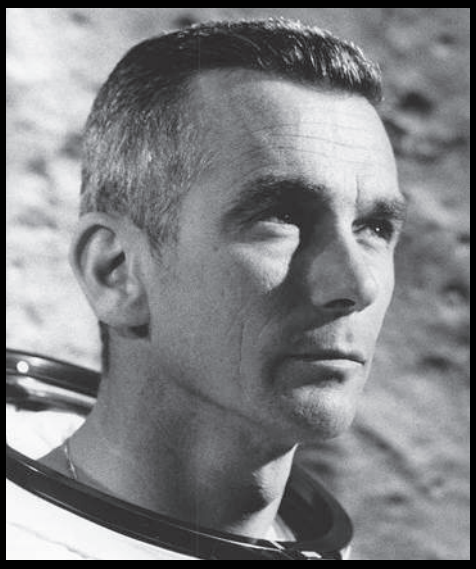
Dick Gordon

"[After filling in management on the Apollo XIII situation] management told us, 'What can we do to help you guys?' It didn't hit me at the moment, but they were really saying 'We trust you guys, and we will find any way we can to help you.'"

Glynn Lunney

"When Apollo was announced I was a fighter pilot in Germany. We had one flight with Alan Shepard. At the time we didn't have much faith in Apollo. But the amazing part about it, is that eight years and two months later we did."

Charlie Duke



A conversation with the LAST ON THE

Eugene Cernan

Forty years have passed since he left mankind's last bootprint on the Moon, but Gene Cernan is a man focused on the future. He strongly believes that inspiring dreams within children, and encouraging STEM education is the path to a future where we walk on the Moon again.

Apollo 17's Gene Cernan and Harrison Schmitt recently spent more than a half hour apiece discussing a variety of topics with *RocketSTEM*. The phone interviews were conducted by Chase Clark, with assistance from Anthony Fitch. The conversations have been edited for length.

Cernan: "What we have to do is reenergize young kids' imaginations. Challenge them to do things they didn't think they were capable of doing. This is what real STEM programs are all about. It's not just teaching math and science and technology. That will come. I've always felt that if you can get a kid's attention, make learning fun, you can teach them, or they can learn anything along the way. That's what our National Flight Academy down in Pensacola, (Fla.) is really all about. Using aviation as the hook. Not to make aviators out of everybody, but hopefully doctors and scientists and engineers and teachers and all the things we need so desperately in this country.

"It starts with that age group, when you get a kid's attention and they can look for something to hold onto. For my generation the challenge was not just for those in the space program, but the challenge for the country in my generation's time, was to do something that had never been done before. To go forth to where we have never been before. And we did it.

"Now we have to impart that kind of challenge, that kind of dedication and commitment into young kids and give them something that they can latch onto.

"I would like to see a commitment for us to go to the Moon. I don't care if it's in the next 10 or 40 years. The time frame is less important than the direction we take and give this generation collectively. give my grandkids, something to challenge them, something to look forward to. Out of that challenge, and I think one of the greatest spin-offs of the space program, particularly in those early days, was education, because I have young men and young women in their 40s and 50s coming out to me today and saying 'Captain Cernan, thank you. I am an engineer. I am a technician. I am whatever I am because of what you did.' Well it wasn't what I did. It was what we, the nation, did at that point and time.

"I think that is the underlying foundation for some real serious STEM programs, but they all need a hook. You can't just put a book in front of a kid and say read it. You've got to have a reason to want to read it. It's got to be a challenge to them. "

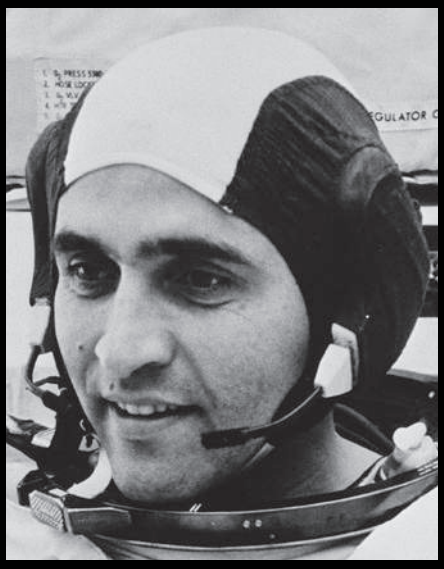
"The Flight Academy is – if anything – it's Space Camp on steroids. We really are a high tech motivating operation. To have a kid come out of there and say 'I didn't know I could do that. Hey, I led a team of kids. Hey, we did it.' And the kid can come out and, if they know they are capable of doing something they didn't know they could do to start with, there's nothing they can't do in their lives. That's what the foundation of a STEM program like the Flight Academy is all about."

Since leaving the Moon for the last time in 1972, mankind has not ventured beyond low Earth orbit. For Cernan, the Apollo 17 voyage marked the end of a distinct era in space exploration.

Cernan: "There are two different space programs. Both technologically, philosophically and spiritually. One is an Earth orbit. And one is when you leave this planet of ours

Continued on page 14

MEN MOON



Harrison Schmitt

Of the 12 men who explored the Moon, only Dr. Harrison 'Jack' Schmitt was an actual geologist. After years spent training those who had gone before him, he blazed a trail for the scientist-astronauts who would later follow him into space.

Schmitt: "Well I think it was important to the space program because it set the stage for scientists and engineers who were not trained in the military, and indeed many of them who were not pilots, to participate in Skylab and Space Shuttle and the International Space Station.

"Now from a pragmatic point of view, that is the important thing, but it also illustrated that whatever you are going to do in space, you want to send people who are professionally expert in a particular field that is important, and that has been, more or less. If you are going to do field exploration on the Moon, the most likely person to do that, the best is a trained field geologist. And in the Apollo program that person also had to be a trained pilot."

While Schmitt did receive pilot training through the military while serving as a civilian astronaut, the experience of exploring the Moon presented other obstacles to overcome once on the surface.

"Well, the main difference in my experience is the time constraint. We had a certain amount of time on the Moon, and we only had a certain amount of time outside the spacecraft for any given day. And then, of course, added to that is the physical constraint of operating in a space suit."

"Now there are some environments on Earth where some or all of those constraints exist one way or another, but in my experience, I felt much more time pressure and physical limitation pressure than in other activities I've felt here on Earth.

Despite the fact that five other lunar missions had been conducted, Schmitt went to the Moon prepared to be surprised.

Schmitt: "I think in the field, when you go into a new area, you have to assume that everything you see, that is new and no body else has seen before, is a surprise. But you go into the field with working hypotheses, hopefully several, to test, and sometimes it pans out that one or the other hypotheses explain what you ultimately see. And other times you have to come up with entirely new hypotheses because of what you have found.

"And the Moon was no different than my work in Norway or Alaska or Montana or other places."

Schmitt only had three excursions over three days to explore the Moon, but the journey proved to be fruitful with the discovery of what appeared to be 'orange soil.'

Schmitt: "The orange soil that I called it at the time, which became known once it got back here as orange volcanic glass, was something that a field geologist, you would like to think, would pick up. It was a pretty subtle coloration. And the debris layer that surrounded the crater Shorty was fairly subtle, but it is the kind of thing that a geologist's eye is trained to pick up.

"It also related to one of the several working hypothesis that I had relative to the origin of that crater that we called Shorty. It looked very much like an impact crater. That was the most probable outcome of the studies. But we had entertained the possibility, based on the low resolution photographs we had, that it could be a volcanic crater.

"When we started to see coloration around it, that triggered in my mind the idea that we see color around the volcanos here on Earth due to alteration of the rocks and that hypothesis might still be valid.

"It didn't take very long looking at the crater Shorty however to be absolutely sure that it was indeed an impact crater so we had to come up with some other explanation for the presence of that orange volcanic glass in its rim.

"That is still an area of some de-

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and head out, in our case a three-day mission to make another body our home, is what we did in Apollo. It's not different astronauts, it's a different space program.

"In Earth orbit you travel around the Earth once every hour and a half, 150, 200, 250 miles above the surface. It's a spectacular place to be. You fly across the ocean in 15 minutes. You cross rivers and cities, and maybe even your own hometown. You see thunderstorms and hurricanes from 100 miles above them.

"That's all pretty spectacular, but let me tell you, you don't see the Earth per se until you leave it.

"When you head on out at 25,000 miles per hour and look back and realize that horizon that was only slightly curved in Earth orbit, somehow closes around upon itself, and all of a sudden you are seeing something very strange, yet very familiar, and you realize you are seeing the entire Earth emerge in your window.

"It gets smaller very, very quickly as you head on out to the Moon until you can literally cover it up with something smaller than the palm of your hand. If your thumb is big enough you can cover it up with your thumb. You no longer fly over rivers and coastlines and cities and hometowns, but you can glance and look, without even turning your head, from what I call the turquoise blues of the Caribbean across the East Coast of the United States, across North America, the plains, the snow covered mountains into the deep dark blues of the Pacific.

"It's over-poweringly beautiful because its surrounded by what I call the infinite blackness – endlessness of space and the endlessness of time. Not darkness, but blackness. There's three dimensional blackness that I can guarantee you does exists because I saw it with my own eyes. And yet within this blackness, three dimensionally, is a dynamic, kinetic moving living Earth dominated by the blues of the oceans and the whites of the snow and the clouds.

"So, let me tell you, technologically it is different because it took a lot more to get you there, it's going to take a lot more to get you home, particularly once you disengage from your mother ship and head on down to the Moon. And philosophically, you can make of that what you want. And spiritually, I will tell you, and I ended up coming to the conclusion on Apollo 10 and reinforced it on Apollo 17, it is just absolutely too beautiful to have happened by accident. There has got to be a creator, call him by what name you want, dress him in any way you want, but there is a creator of the small part of the universe I was privileged to see."

Just four months before heading to the Moon, Gene Cernan takes a break from training to pose with his wife, Barbara, and their daughter, Teresa (Tracy). Dannette Sanders, a friend of Tracy's, is on the left. *Photo: NASA*

Using NASA's Kepler orbiting telescope, astronomers recently announced an estimate that there are at least 17 billion Earth-sized planets just within the Milky Way galaxy. The possibility of life existing elsewhere in the galaxy, and perhaps within our own solar system, is a topic that has been getting serious discussion in recent years.

Cernan: "I saw that in the paper myself this morning, and how little we know. How little we know even of our own galaxy. I mean since I was in grade school, there's been what, I don't know how many planets anymore, because Pluto was a planet and now its not a planet. Now we're saying there's other Earth-like planets in our galaxy. Everyday, every time we reach out, we learn something new. Discovery is what it is all about. Curiosity is the essence of human existence.

"Who are we? Where are we? Are we here alone? And the answer to your question is, statistically there has to be, how many, a billion, a trillion other planets like us in the infinite universe? I don't know. But if you believe as I do that there has to be a creator in the universe, how can we, you and I, be so arrogant to believe that the creator created life here and not somewhere else? Think about that. Will we ever find out? I don't know. I'd like to know.

"Who knows? That is why we go. I tell kids, and I really believe it, that somewhere out there is another young boy or girl, our grandkids, their grandkids, who knows, that are one day going to take us back where no man has ever been before. People ask me all the time will we go back to the Moon? Will we go to Mars? You bet your life we'll go. It will happen."

When the time comes that humans venture back out beyond low Earth orbit, Cernan has a few pieces of advice for those explorers.

Cernan: "I would say, first, the same thing I told Ron Evans and Jack Schmitt, who had never flown before. I said 'Guys enjoy it. You're only coming this way once.'

"The major advice my dad gave me a long time ago...'Whatever it is, you do your best. You're not going to be better than everyone at everything, but someday you're

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bate right now. The most important aspect of the glass though is that it has opened up the real possibility that the water that has been discovered at the poles of the Moon may well be indigenous water, that is water that has come out of the Moon and migrated to the poles.

"Before the water was discovered in the orange volcanic glass – and that happened just a couple years ago – before that was discovered inside of the glass, the dominate hypothesis for the origin of water in permanently shadowed area of the poles, was that it has come from the impact of comets or water-bearing asteroids on the Moon. That is still a very real possibility and it may actually be a combination of several sources of water.

"But certainly the orange volcanic glass and its companion green glass that was found but not fully recognized on Apollo 15, those both have water in them. So, it has opened up the possibility that water has actually come from the interior of the Moon."

Even after 40 years of study, the lunar rocks brought back from the Moon still are revealing their secrets to Schmitt and other researchers.

Schmitt: "The lunar samples are the gift that keeps on giving. There has been a very, very active lunar science community. They continue to come up with not only new ideas on what to test, but new technology on which to run those tests. Forty years ago you could not have detected the water in a small bead of volcanic glass. That was done just recently. Now we have the technology and equipment by which most kinds of analysis can be conducted.

"I continue to try to integrate the new information, both from the soils and from the robotic missions that have gone to the Moon. Most recently the Lunar Reconnaissance Orbiter has provided high resolution photography of most of the Moon, and in particular the Apollo landing sites. I've been going back into that photography to see if it enhances my understanding of what we saw when we were actually there."

Heading out beyond the Moon is a goal that the geologist side of Schmitt definitely sees as the future of space exploration, but he is practical enough to realize that even with such an endeavor, the Moon will likely play an important role.

Schmitt: "I think the most obvious long-term goal, that is also the most technologically feasible in a long term goal, is Mars. But I think the fastest way to get there is to go back to the Moon, and use the Moon not only for a scientific understanding of the Earth and the Moon, but also to develop the techniques necessary for actually carrying out a Mars mission.

"The technology and operational procedures we will need on Mars and going to Mars will be very very different in what we are used to. The Moon however is a place only three days away and operations can be fully developed. Plus the Moon has resources that I think are going to be very important. Not only for providing the necessary consumables for going to Mars, and the protection from space radiation, and the water, but also enable to show us how to operate when you have no workable communications with the Earth.

"The astronauts that work on Mars, the geologists and others that work on Mars, are going to be totally on their own because the communication delay will make it impossible for what we call real-time communication with the Mission Control Center.

"That doesn't mean the Earth won't be involved, but it will be involved as an analytics, support and planning center rather than a place that actively provides real time support, such as we had on Apollo.

"I think most geologists would prefer working on Mars, rather than working on the Moon because there would be less interruptions."

When it comes to STEM educa-

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Harrison Schmitt (facing camera) not only discovered the 'orange soil' of the Moon shown on the right, but he also was one of the first to look at the sample back on Earth. Photos: NASA

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going to surprise yourself.' You have to have enough confidence in yourself. You have to know that you are capable. You have to have a lot of faith in the people who put the hardware together that you're flying. You can't do everything yourself. You need a lot of help.

"It was a collective effort to get to the Moon and it will be a collective effort to get to Mars. You have to believe in yourself, and you have to belief that what you are doing is the right thing to do. If you've got any doubts, then you shouldn't go."

With the in-development Space Launch System rocket potentially bringing new life to the engines that powered the Saturn V, we wondered how Cernan felt about that. The answer was illuminating.

Cernan: "It was a great, great, great machine. It's nice to know that we can go back and use that technology that we've already developed. It's a shame that we've got three, what were operational Saturn Vs, sitting in museums. I hate to see that, but that's the way it is.

"From a simplistic point of view, there's only one way to get into orbit. There's only one way to get into space. You don't have to be overly sophisticated. I think the Shuttle was probably the greatest flying machine we've ever designed, built and flown. But it's not what you do on the way, it's what you do when you get there.

"You could have a big dumb firecracker get you to where you wanted to go. The time, whether it is the 11 minutes to get into orbit, or whether its the three days to get to the Moon, is, I won't say wasted time, because we did a lot on those three days to the Moon and back, but that's not the objective.

"The objective is to get where you want to go and then use all your technology, all your sophistication, and put them all in that package. Having said that, you've got to make that firecracker I'm talking about safe. You've got to make it manageable. In our case, if we lost a guidance on the Saturn V, one switch and I'm flying 7.6 million pounds of thrust. I've got the capability in the palm of my hand. I almost dared it do that, because I knew I could've flown it into orbit.

"I don't want to get one sided, but to me, the objective is to be there. The purpose of us going to the Moon was to be there.

"The SLS, let me just say this about it. We're rebuilding another gigantic capability to put heavy payloads not just in orbit, but perhaps as far away as the Moon. But I think realistically, when we talk about going beyond the Moon, that chemical propulsion is at its limit. We have to find ion propulsion, nuclear, we have to find something else that can get us beyond the Moon. With today's chemical technology we'd have to use the planets and coast to Mars. Nine months to get there and stay there for some extraordinary period of time until the planets got aligned so we can get home. That's unacceptable to me. That won't happen. When we go, we'll be able to get there in 60 days or less, stay as long as we want, and come home when we want. It's going to take some sophisticated new propulsion technology to do that.

"I really believe the Saturn V, the SLS, has met its match when its got a requirement to take us beyond the Moon. Will I be proven right or wrong? Who knows."

Nearing his last moments on the actual surface of the Moon, Cernan knelt down and scratched 'TDC', his daughter's initials, into the lunar soil. It was a simple action that still resonates with children to this day. But why did he do it?

Cernan: "I tend to do things ad lib. I think about things ahead of time, but for the most part I react to the environment, I react to the moment. I had no plans to do that. It just seemed like the thing I ought to do at the time. I parked the rover, about ready to walk back to the LEM and I don't know, I just did it, and I can't tell you why.

"I guess I thought it would be nice to have her initials up there, and people have said 'How long will they be there?' I tell them as long as the flag will be there. As long as my final footsteps will be there. Forever. However long forever is. And that's something none of us can understand. That's a concept of time.

"I don't know. I did it, and you are right, I realized in later years now, that it truly does mean a lot to a lot of kids. They relate to that. Which is good. I'm glad they do."

Photo: NASA/Ron Evans

As the conversation was drawing to a close, Cernan reflected on the need once more to inspire the next generation growing up today.

Cernan: "Going back to the Flight Academy. That's where the future is. The future is in our kids and we've got to give them something. We've got to give them some self reliance and some self confidence and something to reach out for. Something that they can feel good about.

"We need dreamers. Because that is how we got to the Moon. We've got to get these kids dreaming again."

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tion, Schmitt believes that a certain way of teaching mathematics is the key to preparing the next generation of scientists and explorers.

Schmitt: "Mathematics, in particular, opens up a whole new spectrum of possible endeavors to any individual that studies it. Not only endeavors that link to every day life here on the planet, but other opportunities that will come in the future that are presently unforeseen.

"Mathematics is the language of those kind of opportunities, and students really need, more than anything else, is to be able to speak and think in that language much, much better than they normally do.

"I strongly recommend that people who are involved in the so-called STEM fields, that they consider that mathematics really needs to be taught as a language. So that it is readily available, and not something that you look up and have to read about."

For the child of today looking to make the discoveries of tomorrow, both on Earth and in space, Schmitt thinks being prepared can only come with a broad education.

Schmitt: "With any field of endeavor, the teaching requirement is to be prepared. To be prepared not only for that field, but be prepared for that field to change. And the only way you can be prepared to do that is to have a really strong fundamental basic education. Not only in STEM fields. The science, technology, engineering and math – math again should be the first on that list – but also in other fields. Language, history, philosophy, all of those are important parts of your education. Those young people must concentrate on getting as broad and as basic an education as possible so that they will be flexible in the future."

After leaving NASA, Schmitt successfully ran in New Mexico for a Senate seat in the U.S. Congress. He believes it is important that everyone stays informed about happenings in government.

Schmitt: "Everyone needs to be involved in politics, whether they want to be or not. The political field is what determines the way that our society is run, and the way it is governed, and how much liberty we are going to have.

"Most of the trends in recent times have been to restrict liberty rather than to enhance it. And so it is very, very important that people of all walks of life recognize that politics is something that they have to be involved in.

"They have to have as much information as they can gather in order to make the decisions, not only about elections, but about their role in society. That is being lost on an awful lot of people, including lost in our education system.

"But a system that allows the individuals, the voting public, the information they need to have in order to understand that being strong in space has many different benefits. Probably the most important is really related to our national security. That is, that the psychological benefit of the primary defender of liberty on this planet, being active and indeed dominate in space is extraordinarily important in the geopolitical sense."

For Schmitt, the Moon has not been the final frontier, even though he continues to study it. There are still plenty of places to explore and discoveries to be made right here on Earth.

Schmitt: "Oh, no question about it, and that is why science is exciting to most of those people who are involved in it. In that you never know what is going to appear over the horizon, whether it is in the laboratory or in the field.

"The nice thing about geology is that almost any place you go still has places to explore and things to learn. And you never run out of opportunities, believe me."

It's been four decades since Schmitt last walked upon the Moon, and despite the fact that none have followed since, he does hold out hope for the future.

Schmitt: "It was very clear when I became the 12th person to step on the Moon, that there was not going to be any person to do that for some time. Now, did I think it would really be 50 or 60 years before that happened again? No.

"I am very disappointed that we still do not have a coherent plan to get back to the Moon and gather the scientific understanding that is waiting for us there, as well as the resources that are there.

"But again, I'm an optimist, I think if we get our education system put in great shape again, young people will lead us to the Moon, as they did in Apollo.

"That's one of the things you have to remember is that Apollo was a young persons program. The vast majority of people in Apollo were in their 20s. And that is what makes these kinds of things happen. Young people with a good basic education, and also the motivation and stamina and imagination to really take on these kinds of projects.

"I run into them every day."

Final voyage to the Moon

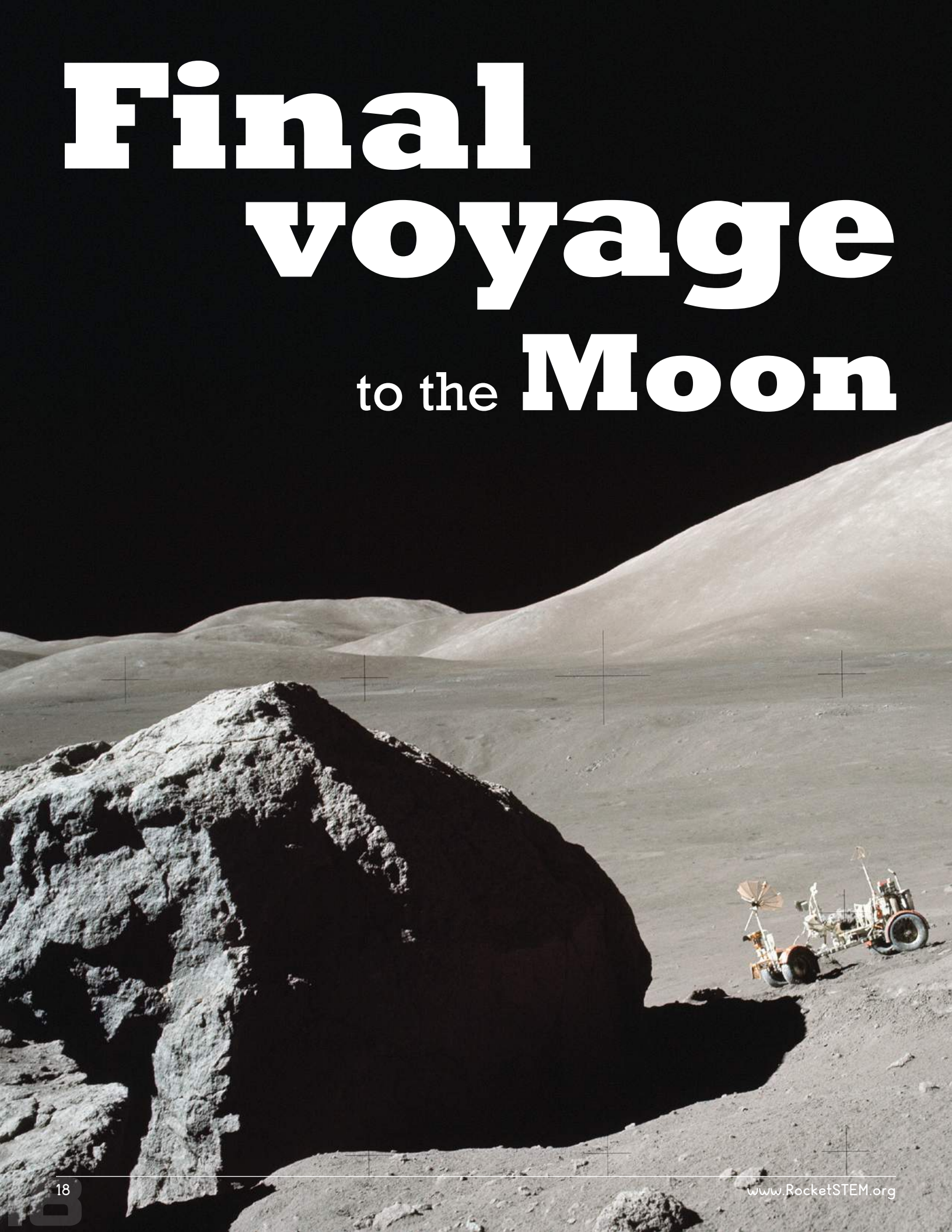


Photo: NASA

Forty years ago, humanity left its last footprints on the surface of another celestial body.

Apollo 17 astronauts Gene Cernan and Harrison 'Jack' Schmitt guided their lunar module Challenger down into a beautiful, mountain-ringed valley in the Taurus Mountains, on the edge of the Moon's Serenitatis basin, just south of the ancient crater Littrow.

Authored by Ben Evans, this article originally appeared online at AmericaSpace.org. Many of the mission photos have been provided by Retro Space Images.

Chapter One:

Picking the Men

Apollo 17 crewmembers Gene Cernan and Harrison Schmitt work together during a lunar EVA simulation at Kennedy Space Center in Florida. They are the last humans to walk upon the surface of the Moon.

Photo: NASA via J.L. Pickering/ Retro Space Images

The spectacular landing site had been selected in February 1972, having been extensively photographed from orbit during the Apollo 15 mission. When they visited 'Taurus-Littrow', Cernan and Schmitt achieved the exalted goal of setting foot on an alien world... and left a gaggle of disappointed fellow astronauts back on Earth.

To understand the crew-selection process in that long-gone era, the central character was Deke Slayton, an astronaut himself and since the early 1960s served as NASA's head of Flight Crew Operations. In the early Apollo period, he developed a three-flight rotation system, whereby the astronauts on the backup team of a given mission would fly as the prime crew three missions later. Hence, the Apollo 9 backup crew of Pete Conrad, Dick Gordon and Al Bean were recycled as the Apollo 12 prime crew.

It would make sense to suppose that the Apollo 14 backup crew – Gene Cernan, Ron Evans and Joe Engle – would thus have been in pole position to take the Apollo 17 seats. Had NASA not been required by Congress to cancel its last two Apollo landing missions, it is quite possible that this is what would have happened.

But there was a problem. On the Apollo 15 backup crew – and therefore probably pointed toward the Apollo 18 prime crew – was NASA's only professional geologist-astronaut, Dr. Schmitt, and the space agency had long been under intense pressure from the National Academy of Sciences to fly him to the Moon.

Since his selection by NASA in 1965, Schmitt had worked extensively on Apollo, covering the lunar surface experiments packages, the lunar module descent stage systems and other elements of cargo and tools. He single-handedly came up with a lunar-orbit science plan for Bill Anders to follow on Apollo 8 and was closely involved in the geological training of subsequent landing crews. It paid off.

In March 1970, Schmitt's name was formally announced on the Apollo 15 backup crew. Joining him would be Dick Gordon as his commander (and lunar-landing buddy) and command module pilot Vance Brand.

For the scientific community, it was a moment of triumph. Many had pushed for a geologist to be aboard the first lunar landing mission, although the engineering demands of that flight made it relatively easy for NASA to snub them. However, as successive Apollo crews – all military pilots – journeyed to the Moon, it became harder and harder for the space agency to explain away their decision not to include Schmitt.

When Apollo 18 was cancelled, the men who would have served as its crew were deeply disappointed, but Gordon felt that with Schmitt on his team there was a very good chance that Deke Slayton might overlook the rotation system and assign them to Apollo 17 instead.

Then, on 23 January 1971, an incident in Florida' Banana River seemed to improve the chances of Gordon's crew significantly.

On that day, Cernan, in his role as Apollo 14 backup commander, was flying a tiny Bell H-13 Sioux helicopter

– a type which became famous in M*A*S*H – on a training mission. The chopper was routinely employed by Apollo commanders as a tool for lunar landings.

Cernan flew down the Atlantic side of Cocoa Beach, over Melbourne and back up the Indian River towards the Cape. Mischievously, he decided to 'flat-hat' the river, but as he looked at the reflective bottom his eyes lost touch with the water. One of the helicopter's skids touched the calm surface of the river and the H-13 crashed in a spectacular explosion.

"Spinning rotor blades shredded the water, then ripped apart and cartwheeled away in jagged fragments," Cernan wrote in his memoir, *The Last Man on the Moon*. "The big transmission behind me tore free and bounced like a steel ball for a hundred yards before going down. The lattice-like tail boom broke off and skittered away in ever-smaller pieces, the plexiglas canopy surrounding me disintegrated, one of the gas tanks blew up and what remaining of the demolished chopper, with me strapped inside, sank like a rock."

Miraculously, Cernan survived and swam to safety through water coated with burning fuel. Boaters hurried to his aid. After being patched up at Patrick Air Force Base, Cernan – his eyebrows singed and his backside charbroiled – strode into the crew quarters to see an astonished Al Shepard, commander of the Apollo 14 prime crew, having breakfast.

In true 'Right Stuff' fashion, Cernan told Shepard that things were so boring at the Cape, he had to do something to get some publicity for Apollo 14!

"Right!" Shepard grinned.

Deke Slayton, though, was in no mood for humour. At first, he tried to give Cernan an easy way out before talking to the press – offering to tell them that the helicopter itself was to blame, that its engine had failed. No, Cernan told him, "it didn't fail. I just screwed up."

When the investigation board, chaired by astronaut Jim Lovell, published its report on the accident in October 1971, it concluded that "misjudgement in estimating altitude…[was] the primary cause". In admitting blame and telling the truth, Cernan knew that he may have screwed his chances of someday commanding Apollo 17, but was aware that honesty went a long way with Deke Slayton.

On 13 August 1971, NASA formally announced the prime Apollo 17 crew. Slayton was unprepared to break up 'core' Apollo 14 backup crew of Cernan and Evans...but bowed to pressure and added Schmitt as the mission's lunar module pilot.

That spelled particularly bad news for Dick Gordon and Vance Brand, obviously, but perhaps the person who suffered the most was Cernan's original lunar module pilot, Joe Engle. Writing two decades later, in his landmark book *A Man on the Moon*, Andrew Chaikin noted that Engle's toughest challenge in those bitter days was explaining to his children that he was not going to the Moon.

This does not imply that Slayton had no confidence in Engle; quite the opposite, for Engle was a former X-15 pilot, with three flights above 50 miles, and would later earn renown as the only astronaut to fly the Shuttle wholly manually from the de-orbit through the atmosphere to touchdown.

Harrison Schmitt, Ron Evans, and Gene Cernan stand at the base of their Saturn V rocket during a visit to the pad just days before the launch of Apollo 17.
Photo: NASA via J.L. Pickering/ Retro Space Images

Cernan described him as "a magnificent aviator", but admitted that Engle was not as knowledgeable about the lunar module's quirky systems as he would have liked. To Cernan, it mattered little, for his experience from Apollo 10 imbued him with the skills to carry both of them, and Slayton retained sufficient confidence to recommend the names of Cernan, Evans and Engle to NASA Headquarters as the Apollo 17 prime crew.

It was rejected.

Jack Schmitt, the geologist, simply had to be aboard the final lunar landing mission. Indeed, high-level management discussions had been in progress since March 1971 and NASA Associate Administrator for Manned Space Flight Dale Myers had written to Charlie Townes, chair of the Space Sciences Board of the National Academy of Sciences, assuring him of his support.

Cernan and Evans and their wives, Barbara and Jan, were vacationing in Acapulco when Slayton called them with the Apollo 17 news. Cernan flashed a thumbs-up to Evans, to signify that the two would fly together, but was stopped short in his tracks when Slayton called him back to Houston to "discuss" the rest of his crew.

"The four of us adjourned to the bar for a few rounds of rum and Coke," he said of that evening on Mexico's Pacific coast, "elated because we had gotten what we wanted, but disappointed, too. Even without being told, we knew that Deke probably had been forced to shuffle the crew, that Jack was going to fly and Joe was going to stay home."

Engle was bitter, but handled his predicament with grace and dignity. A month later, on 8 September, he told Jim Maloney of the Houston Post that "when something like this happens, you can do one of two things. You can lay on the bed and cry about it, or you can get behind the mission and make it the best in the world".

> "You can lay on the bed and cry about it, or you can get behind the mission and make it the best in the world".
>
> – *Joe Engle*

It is testament to Engle's integrity and strength of character that he put his own feelings to one side and rededicated himself to helping Schmitt perfect his skills as a lunar module pilot.

The wives thought differently, at least at first. Barbara Cernan and Jan Evans had formed close relationships with Joe and Mary Engle and were devastated at the loss. Schmitt was a bachelor and Cernan worried about whether he could mould the civilian into a member of his team.

Schmitt apparently had little regard for the military chain of command to which most astronauts had become accustomed.

At length, Cernan sat Schmitt down with the bottom line. NASA may be a civilian agency, but its leaders came from military services, where the commander's word was final. "We could discuss differences and problems," Cernan wrote in his memoir, "but the old Supreme Being argument had to apply."

The consensus was that Schmitt would work through Cernan, like it or not. Or in Cernan's words: "Period. End of story. Sit down."

Schmitt sat down. In time, the duo developed immense respect for each other and Cernan gave his geologist responsibility for planning virtually every science aspect of their three days on the Moon.

Unpicking the Men

The names of Cernan, Evans, and Schmitt were revealed by NASA on 13 August 1971 and, in keeping with convention, the identities of a backup crew were also publicized.

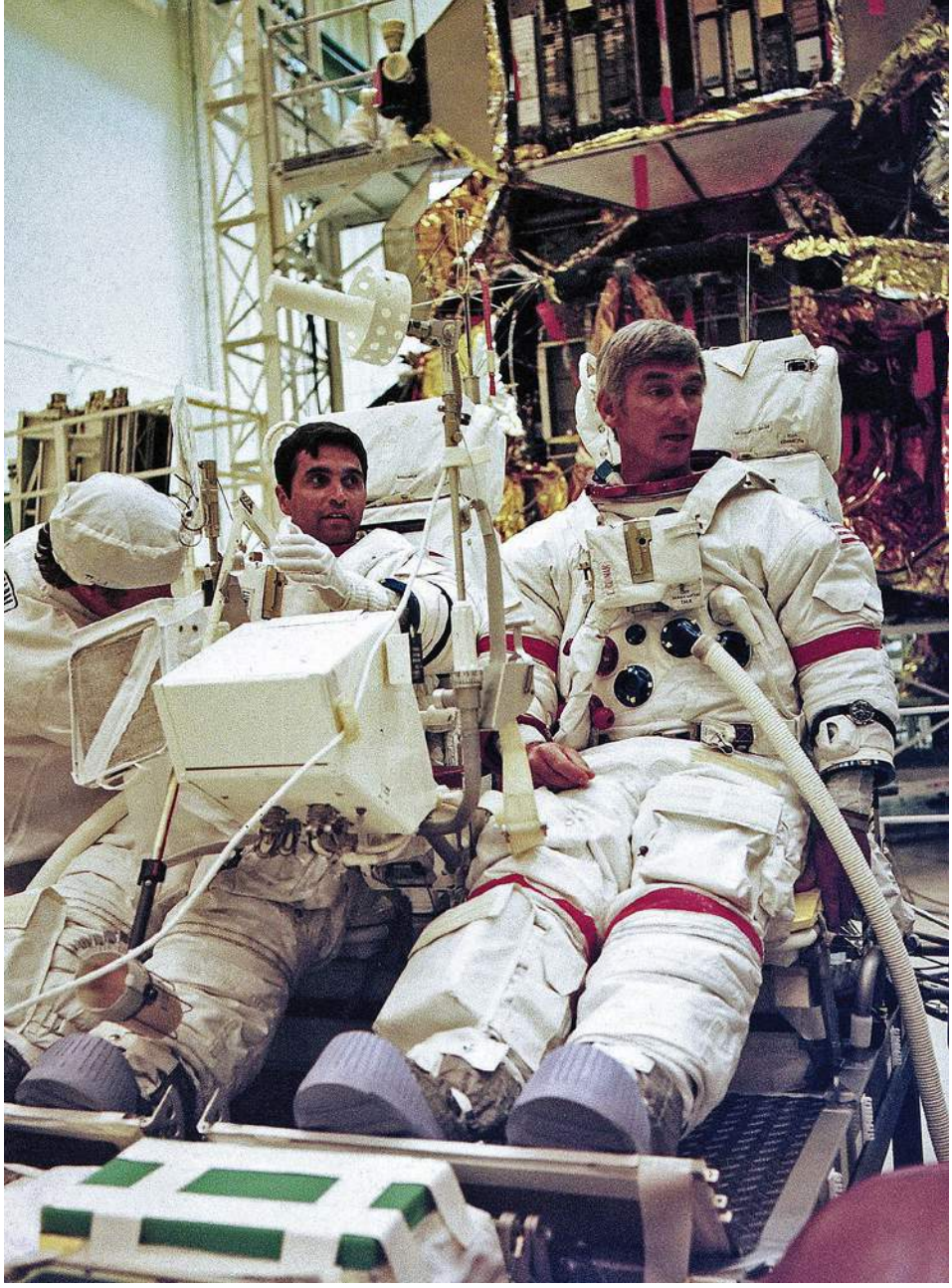
Since Jack Schmitt was the only professional geologist in the astronaut corps at the time, it seemed unlikely that even a broken leg would prevent him from flying, and the backup team knew this.

Assigned to this somewhat unenviable role were astronauts Dave Scott, Al Worden, and Jim Irwin, who had recently returned from the Moon on Apollo 15. However, their assignment was terminated a few months later, when the three men became embroiled in a particularly ugly scandal which would tarnish their individual reputations as well as the astronaut corps itself.

Scott, Worden, and Irwin had carried a stack of first-day philatelic covers to the Moon on Apollo 15, part of an arrangement with a stamp dealer, with the intention of selling them and setting up trust funds for their children.

The problem was that the 400 total covers—a hundred for each astronaut and the remainder for a German dealer, Walter Eiermann—had not been authorised by NASA. According to the terms of the deal with Eiermann, the covers would be sold exclusively (and privately) to collectors, with no publicity, after the end of the Apollo programme, with Scott, Worden, and Irwin expecting to receive around $8,000 apiece.

Eiermann, however, began selling them within weeks and the furious astronauts contacted him in October 1971 and tried to cancel the agreement. It was too late. The story had leaked into the European press and some covers were already fetching $1,500 each.



Harrison Schmitt and Gene Cernan participate in a check out of the lunar roving vehicle and all its systems at Kennedy Space Center. *Photos: NASA via J.L. Pickering/Retro Space Images*

It is important to stress that none of the astronauts accepted any money and when Dave Scott admitted to senior managers what happened he was met with NASA's full fury.

Neither Deke Slayton, the head of Flight Crew Operations, or Chris Kraft, the incoming head of what would become the Johnson Space Center, knew if their activity was wrong or illegal, or not, but they knew it did not smell good. They passed the case to NASA Deputy Administrator George Low, who involved the space agency's inspector-general and lawyers.

"In a matter of days," wrote Kraft in his memoir, *Flight*, "we had a full-scale internal scandal on our hands." Scott, Worden, and Irwin were removed from active flight status and dropped from the Apollo 17 backup crew.

Their replacements, formally announced in July 1972, were another mix of previous lunar voyagers: newly-returned Apollo 16 moonwalkers John Young and Charlie Duke, teamed with veteran Apollo 14 command module pilot Stu Roosa.

Previously, Slayton tried to offer positions to "rookie" astronauts, but with no more missions on the horizon there seemed little sense in training

first-timers for a "dead-end" backup stint. For his part, Roosa accepted the Apollo 17 assignment, even with a one-in-a-million chance of flying, but Duke—who would back up Jack Schmitt—knew that he would never fly.

For John Young, he would stick around for whatever missions he could get…and late in 1972 he came within a whisker of seizing the Apollo 17 command for himself.

During their time together, the new backups developed a camaraderie and even jokingly grew moustaches. John Young added more depth in his memoir, *Forever Young*. "We supported the Apollo 17 crew as best we could,"

> "We all grew moustaches and vowed not to shave them until those guys got off the launch pad."
>
> – *John Young*

he wrote. "Honestly, Charlie and Stu and I never wanted anything but the prime crew actually to make the launch; in fact, the three of us all grew moustaches and vowed not to shave them until those guys got off the launch pad."

By the time the new backup team began training, Cernan and his men had already completed a dozen geology field trips and Young's crew joined them for visits to Stillwater in Montana, the Nevada nuclear test site, Tonopah in Nevada, Blackhawk Landslide in southern California's San Bernardino Mountains, the inhospitable Mojave Desert, and Flagstaff—where Jack Schmitt had earlier worked as an astrogeologist—in Arizona.

On one of those occasions, near Tonopah—midway between Reno and Las Vegas—the backup crew's geologist driver sheared off part of the suspension system of his station wagon and left them stranded on the cusp of sundown.

"The Apollo 17 prime crew was two miles away in a different vehicle," wrote Young, "and about to begin driving back to Tonopah. I ran all that way to get them to stop by waving my arms. They did stop, picked me up, and went back up the hill to get Charlie and our geology trainers."

Had Young not done this, they would have been obliged to spend the night in the desert with no camping equipment. "It would not have been a fun night out of town," Young concluded.

Gene Cernan practices with a lunar drill during lunar surface EVA simulations at the Kennedy Space Center.

Photo: NASA via J.L. Pickering/Retro Space Images

By the time that Young, Roosa, and Duke joined the mission, a primary landing site for Apollo 17 had been chosen. In November 1971, the planning process began.

In the '*Apollo Lunar Surface Journal*,' Eric Jones wrote that "the flight planners wanted a site far enough from the [Moon's] eastern limb that they would have at least 12 minutes of flying time—and preferably 15 minutes—before Acquisition of Signal and the start of the final descent." This enforced a demand of possible sites being no further east than a lunar longitude of 34 degrees, and in a memo dated 23 November, Jim McDivitt, head of the Apollo Spacecraft Program Office, declared that only in cases of extraordinary scientific merit should a site outside those parameters be considered.

The final decision of the Taurus-Littow valley was made in February 1972. Ironically, one of the key factors in the decision was the imagery acquired by the Apollo 15 crew from lunar orbit.

Years later, Cernan wrote that the site was so far off the "usual" track that it did not have a name and was thus dubbed 'Taurus-Littrow'. Its steep-sided mountains were expected to yield rock and soil samples from before the calamitous Mare Imbrium impact—a major collision event in early lunar history, which produced a 700-mile-

Ron Evans suited for a Command Module altitude chamber test on July 31. 1972.

Photo: NASA

wide crater that is today best recognized as the Man in the Moon's right eye—and its dark-colored surface was peculiarly distinct from the brighter highlands around it.

In fact, the valley possessed some of the darkest material ever seen on the Moon.

"The targeted landing point itself," explained the NASA news release on 16 February, "will be on the other prime sampling objective, which is the very dark, non-mare material filling the valleys between the mountains."

On Earth, such geological events can occur when pockets of high-pressure volcanic gas find release at the surface and spray droplets of lava in a veritable "fire fountain"; if this had happened at Taurus-Littrow it was expected to have blanketed a wide area with volcanic material.

During his observations from orbit on Apollo 15, Al Worden described what he thought were "cinder cones" in the region and suggested over the radio that it might be a highly desirable spot for a future landing.

If Taurus-Littrow was volcanic in origin, its relatively low crater density and dark material led to intense speculation that it was one of the youngest such areas on the Moon. At the same time, the North and South Massifs, which bounded the valley, were expected to produce more ancient rocks and the Sculptured Hills appeared to hint at highland volcanism.

If Charlie Duke intuitively knew that he would never gain a seat on Apollo 17 for real, that opportunity came tantalizingly close for John Young, in spite of his assertion that he wanted nothing more than for the prime crew to fly.

Two unexpected situations arose in the latter part of 1972. The first came in the weeks after the infamous massacre of Olympic athletes in Munich in early September, and there was talk that Black September militants were targeting the high-profile Apollo 17 crew and their children.

Cernan was incensed by this threat to their children's lives and in the final weeks before launch armed police sat in unmarked cars, 24 hours per day, monitoring the astronauts' homes. Meanwhile, during the day, well-dressed, exceptionally polite and heavily-armed federal agents sat in the classrooms of the Cernan and Evans children.

During this time, a routine physical exam showed up a prostate infection in Cernan himself. Dr. Chuck La Pinta, the flight surgeon, kept discreetly quiet and treated him accordingly. Years later, Cernan would praise La Pinta as one of few doctors who did not ring alarm bells… but then something else happened which almost scuppered his chance of flying Apollo 17 altogether.

One day in October, the crew was playing softball at Cape Kennedy, when Cernan felt something "snap" in his right leg. Fearing a ruptured tendon, he had to be carried away by Evans and Schmitt.

La Pinta's prognosis was not good. If the tendon was ruptured, it would take months to heal—and Apollo 17 was scheduled for launch in barely six weeks' time—and if not it would still require several weeks of bedrest and time on crutches. Thankfully, when the X-ray results came back, they showed no rupture, but La Pinta told Cernan categorically not to overly tax himself. If he did, the tendon might tear and his chance of flying Apollo 17 would be gone for good.

La Pinta kept Cernan shielded from the managers, who feared the worst. At length, the doctor's treatment and advice worked and Cernan later paid glowing tribute to La Pinta for his discretion. He was, wrote Cernan, "a great doctor, a terrific liar…and an even better friend."

Dr. Chuck La Pinta was "a great doctor, a terrific liar...and an even better friend"

– Gene Cernan

End of the Beginning

The National Academy of Sciences had long pressured NASA to fly its only formally qualified geologist-astronaut, Schmitt, on a lunar landing mission and the space agency eventually caved in.

Yet flying Schmitt on Apollo 17 simply because he happened to be a geologist, and had contributed enormously to the programme, was not enough, and NASA senior managers would have fought the scientists and politicians tooth and nail if the man nicknamed 'Dr Rock' was not up to the task.

Many questions were asked as to how useful Schmitt would really be – encased in a bulky suit, with only minutes available at each geological sampling stop to make judgements and observations – and the fact remained that going to the Moon was fraught with intense risk.

One day, early in 1972, Chris Kraft – the legendary flight director who had recently been appointed Director of the Manned Spacecraft Center in Houston – took Gene Cernan to one side.

"Geno, put away that fighter's silk scarf and just bring your crew home alive."

– Chris Kraft (to Cernan)

"Geno," he began, "put away that fighter pilot's silk scarf and just bring your crew home alive. If you run into something you don't like out there and decide not to land, I'll back you one hundred percent."

Cernan felt quite differently. The very fact that Apollo 17 was to be the final mission of the programme made him even more bold, and he impressed on the journalists, the workers building and checking out their spacecraft and the politicians that this was not the 'end', but the 'end of the beginning'.

Technicians check Apollo 17 Mission Commander Gene Cernan's spacesuit during preflight preparations before boarding and launch of the Saturn V rocket. *Photo: NASA*

However, as our generation knows, Apollo 17 was the end. For two years, NASA's workforce had been in decline and President Richard Nixon's budget cuts had made this immensely painful for those giants who had made possible the greatest achievement in human history.

Although Cernan meant it with all sincerity, his words grew to become a popular joke: a cartoonist drew a pair of workers at the top of a scaffold, one holding a notice informing him that he had just been fired. The other man was on the telephone, saying "Can we get Gene Cernan up here to give Smith that 'it's not the end, it's the beginning' speech again?"

By the evening of 6 December 1972, all was ready. The gigantic Saturn V gleamed under the floodlights as it was readied for its only night-time launch. Even today, it remains the largest and most powerful rocket ever brought to operational status.

Cernan, Evans and Schmitt proceeded through the ritual of a steak-and-eggs breakfast, after which they were helped into their bulky suits. At length, all three men were ensconced in their seats in the command module, which they had named 'America'.

Launch was scheduled for 9:53 pm EST, at the start of a four-hour 'window', and the countdown proceeded smoothly...until the first glitch reared its head. The automated launch sequencer on the ground failed to properly command the oxygen tank of the Saturn V's third stage to pressurise. The launch controllers issued the command manually, but the sequencer knew that it had not sent the command and refused to proceed. Eventually, a work-around procedure was devised and the countdown clock resumed ticking a few minutes before midnight.

Finally, at 12:33 am on 7 December, the Saturn took flight, stunning the assembled crowds and most of America's East Coast

with a spectacle rivalling sunrise. "It's lighting up the sky," announced public affairs commentator Jack King with astonishment. "It's just like daylight here at the Kennedy Space Center!"

From his left-hand couch, Cernan could clearly see the fiery glow reflecting off the clouds and the shuddering cabin seemed 'painted' with a fearsome reddish hue. Ron Evans and Jack Schmitt, experiencing their first ride into space, were jubilant.

Shortly after midday on the 11th, the command and service module America and lunar module Challenger parted company in orbit around the Moon and Cernan and Schmitt steeled themselves for their Powered Descent to land at Taurus-Littrow. By this time, Cernan was an old hand at such matters, having flown down to just nine miles above the Moon on Apollo 10.

"Thanks to the simulators back on Earth, with their computer-enhanced photos of the approach to the landing site," Cernan wrote in his autobiography, *The Last Man on the Moon*, "I knew this place better than I knew my own palm and there were no surprises as we zoomed toward the jagged highlands that separate the Sea of Tranquillity from the Sea of Serenity. I called out the passing landmarks that verified we were on track to the narrow entrance to the Valley of Taurus-Littrow."

The final Saturn V rocket to carry mankind into space launches on the Apollo 17 mission. Below, the rocket is shown at night with the Moon in the background.

Photos: NASA via J.L. Pickering/Retro Space Images

Dropping closer now, both men's eyes remained on their instruments… until Cernan spotted something that he wanted Schmitt to take a look at. Halfway through the 12-minute burn of Challenger's descent engine, he told Schmitt to look at "something spectacular" outside his window. Expecting to see some unexpected jewel of lunar geology, Schmitt looked; but he couldn't see a thing, he said, except for the blue and white globe of Earth.

"That's what I'm telling you to look at!" chuckled Cernan.

Two miles above the Moon, and by now plunging like a fast elevator, the Earth hung in the black sky, directly in front of Challenger's triangular windows.

"Down we flew toward crop-duster altitudes," Cernan wrote, "scooted over the dome-like Sculptured Hills, some of which were more than a mile high, and roared into the eastern entrance of a crater-pocked lunar valley deeper than the Grand Canyon, surrounded by mountains whose crests were above us."

As Schmitt called out altitudes and approach angles, Cernan confidently set Challenger down on a smooth spot at 2:54 pm EST.

At last, less than five days since leaving Florida, they were here. Paradoxically, the cacophony of roaring and groaning and screaming and shuddering which the Saturn V had unleashed as it climbed for the heavens were gone…to be replaced by the absolute silence, ethereal stillness, perfect serenity and utter lifelessness of the Moon's Taurus-Littrow valley. To their right, the North Massif stood taller than eight Eiffel Towers and to their left the "wretched slab" of the South Massif equalled the height of half a dozen Empire State Buildings, stacked one atop the other.

View of the Earth as seen by the Apollo 17 crew traveling toward the moon. This translunar coast photograph extends from the Meditierranean Sea to Antarctica.
Photo: NASA

Four hours later, at 6:54 pm, Cernan shuffled his way down Challenger's ladder and planted his boots into the soft lunar regolith. Shortly afterwards, he was joined by Jack Schmitt and the men set about their first tasks.

Moving around was tricky to start with: only ten other humans had gone from terrestrial gravity to weightlessness to one-sixth gravity and Cernan and Schmitt bobbed around like rubber ducks in a bathtub. At length, the geologist in Schmitt overcame the awestruck voyager: the soil, he radioed, looked "like a vesicular, very light-coloured porphyry of some kind; it's about 10 or 15 percent vesicles". It was also extremely dirty; the dust clung to their suits, to their visors and to their gloves, with the result that within minutes Cernan looked like he had been outside for a week. Trying to brush it away made matters worse.

At one point, reaching to pick up a rock, Schmitt slipped and, laughing, tumbled into the dust: his pure-white suit ended up charcoal grey from the knees down...

"You adapt very, very quickly," Cernan later told Eric Jones of the 'Apollo Lunar Surface Journal'. "You very quickly realise – probably in the first couple of minutes – that you don't need to take baby steps or regular steps to get anywhere.

"Somehow your brain and your body co-ordinate your movements and if you're going to go any distance, you start skipping or hop-skipping to get where you're going. It's not like you start running," contnued Cernan. "It's just that you move with such ease. Later on, when you start moving at faster paces than we were doing here, if you decide to turn or change directions, you have to think about your high centre-of-mass and plan how you're going to handle that... or you're going to go tail-over-tea kettle...but you adapt very readily, physiologically and psychologically. You're conscious, as soon as you're on the surface, that you're in this one-sixth-G environment and that you can move around so much more easily. The human being is a very unique, very adaptable creature."

Their first major task was to unpack the lunar rover from Challenger's descent stage; for the next three days, they would rely upon its capabilities. Unreeling lanyards and watching the framework fold into place was, wrote Cernan, like assembling a Christmas bike for his daughter, Tracy. "Hallelujah, Houston," yelled Cernan as he took it for a test drive. "Challenger's baby is on the roll!"

As they loaded their tools aboard the rover, Cernan kept looking up at the Earth, hanging like a decoration in the sky above the South Massif. At one stage, he even told Schmitt to take a look for half a minute: the geologist owed himself that much. Schmitt, a man who had spent his life exploring the rocks and soils of that blue-and-white world, feigned disgust.

"What? The Earth?"

"Just look up there!"

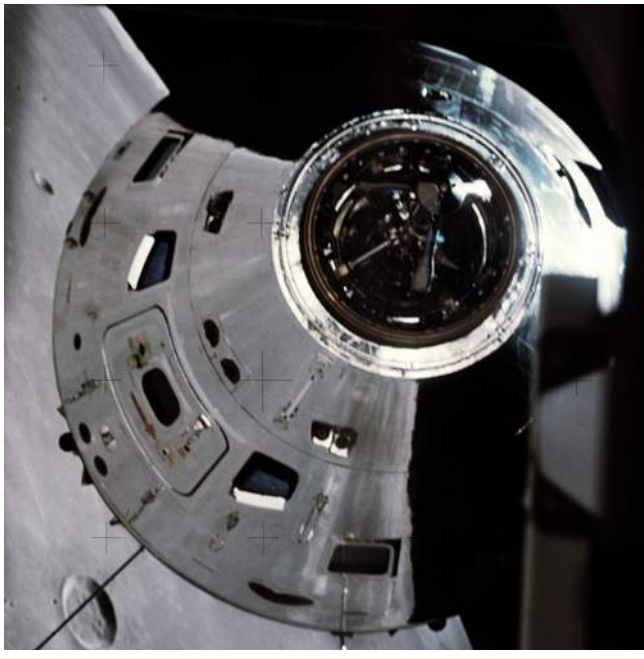
"Aaaahhh," drawled Schmitt. "You seen one Earth, you've seen 'em all!"

By now Cernan was familiar with Schmitt's dry humour and good-natured sarcasm, but in his autobiography he expressed disappointment at how off-handedly the geologist dismissed this awe-inspiring sight.

Before the launch, Cernan had urged Schmitt and Ron Evans to embrace each and every experience from this mission since it was sure to be the most remarkable and breathtaking and exhilarating adventure of their lives, and he also knew that none of them would ever come this way again.

It was perhaps with this in mind that, after erecting the Stars and Stripes, during which Cernan managed to capture a now iconic image of his colleague with Earth in the background, they set to work assembling their own package of experiments, the Apollo Lunar Surface Experiments Package (ALSEP), which would relay data from this strange place.

Many of the ALSEP experiments on Apollo 17 were new ones. The Lunar Ejecta and Meteorites investigation



The Apollo 17 command module seen from the lunar module during rendezvous and docking maneuvers in lunar orbit.
Photo: NASA

tracked tiny particles impacting the surface.

A seismic profiling sensor featured four geophones arranged in an equilateral triangle – one at each point and one in the centre – which measured small explosive charges to be detonated after the astronauts had left the Moon, in order to better understand the structure of the surface.

Elsewhere, another instrument monitored the tenuous lunar atmosphere. A 'gravimeter' was carried on the rover to investigate the deep structure of the valley floor. A second gravimeter, of a completely different type, was set up at the ALSEP site. This was a speculative venture.

Although Einstein's theory of relativity predicted the existence of gravity waves, they had proved difficult to confirm. Working with a counterpart on Earth, any signal detected by just one instrument could not be a gravity wave, but a signal sensed by both could only be a gravity wave passing through the Solar System. In effect, this instrument was a highly sensitive seismometer.

Geophysicist Marcus Langseth, sitting in Mission Control in Houston, was pleased to see Cernan boring three holes into the surface for his heat-flow investigation, although it was tough work. "I had to grip it tightly," wrote Cernan, "and force my whole weight on it, but progress was no better than haphazard. The drill would find easy access for a few inches, then clunk against rock and kick back. My heart rate went up to 150 beats per minute, my hands hurt from squeezing the handle and dust swirled in a sticky haze."

Cernan's increased heart rate alarmed flight surgeons and he ate seriously into his oxygen supply. After a while, Flight Director Gerry Griffin told Capcom Bob Parker to ask Schmitt to help Cernan extract the deep core sample from the ground. For his own part, the geologist had his own troubles with the gravimeter – it needed to be perfectly level and, at length, a slightly exasperated Schmitt was forced to give it a good whack with one of his tools to 'adjust' it.

Harrison Schmitt stands next to a huge, split boulder on the sloping base of North Massif during EVA-3 at the Taurus-Littrow landing site. *Photo: NASA*

In a sense, his efforts were in vain, because when the instrument was commanded to 'uncage' its sensor, a flaw in the mechanism prevented it attaining the sensitivity needed. Still, the instrument was able to detect normal seismic activity.

Called over to help Cernan, Schmitt tried to throw his weight on the jack that was being used to extract the core tube...and abruptly lost his balance and fell flat on his face. This prompted a few chuckles from Houston, but Cernan was worried: had his partner damaged the precious machinery in his backpack? Thankfully, Schmitt was quickly back on his feet.

By the time they finished with the core sample, they were 40 minutes behind schedule. Their first geological traverse would have to be shortened. "Instead of the mile-and-a-half trip south to [the crater] Emory," wrote Cernan, "we would stop halfway, in a boulder field near the crater Steno."

Schmitt was unhappy at losing part of their traverse – in fact, at their single geology stop somewhere near a crater named Steno, they could do little more than grab a few rocks and a bagful of cobbles and dust with the lunar rake.

Back in the vicinity of Challenger, Schmitt spontaneously broke into song:

"I was strolling on the Moon one day..." he began.

Cernan joined the duet: "...in the merry, merry month of December... no, May!"

"May!" confirmed Schmitt.

"May's the month!" confirmed Bob Parker.

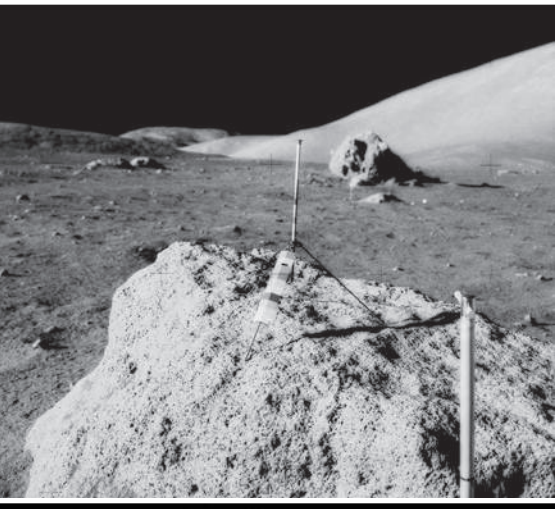
Schmitt continued: "...When much to my surprise, a pair of bonny eyes..."

"Sorry, guys," Parker interjected, "but today may be December!"

Returning inside the lander after more than seven hours, the two men were exhausted: their forearms ached and, after removing his gloves, Cernan noticed blood under his fingernails, undoubtedly from time spent struggling with the drill.

In his autobiography, he also recalled the unusual sensation of repressurising Challenger's thin-walled cabin: it was almost as though an oil can had suddenly been filled with air. A loud 'bloop' noise was followed by the pressure forcing the hatch to visibly bulge outwards. It reminded Cernan of his visits to Grumman and made him realise how fragile this machine really was.

During their time inside the lander, the astronauts stored their suits at the back of the tiny cabin. However,



they were sodden with sweat and in order to dry them in time for the second EVA, Cernan and Schmitt attached the helmets and gloves and hooked up the oxygen hoses to circulate air through them.

"That was like inflating a pair of big balloons," wrote Cernan, "and it seemed as if two more guys had just crawled into our lunar pup tent." Their massive backpacks, meanwhile, were hung on the walls.

They had a quick dinner, then debriefed over the radio with Mission Control and, for a few moments, rolled a couple of the rock samples over in their hands. Cernan was amazed. These pieces of regolith had lain undisturbed for maybe three billion years and had been exposed to fearsome solar and cosmic radiation...yet they did not look totally different to samples he had seen on his geology trips on Earth.

By the time Cernan and Schmitt dozed off to sleep for their first night on an alien world, they had already been awake for nearly 24 hours. Like previous crews, they strung their hammocks – Schmitt near the floor, Cernan above – and even without their pressurised suits it could hardly be described as comfortable.

Initially, Cernan was too keyed-up to sleep; his mind raced with plans for tomorrow's excursion, which was to take them to the South Massif. Every so often, he heard Schmitt breathing steadily, and sneezing occasionally in the midst of so much dust, but otherwise the lander and everything around it were eerily still and silent.

There was no hushed breeze or patter of raindrops, Cernan wrote, or the slightest hint of anything else alive, save the two of them. He was physically and mentally exhausted, yet the irony of sleeping when they only had about 60 hours left on the surface seemed too much: at times, he lifted the window blind and gazed outside at the motionless flag and the Earth slowly rotating in its fixed position above the South Massif.

Show on the left column and top of the next page are photos taken by Cernan and Schmitt during their three EVAs to explore the Moon. *Photos: NASA*

Chapter Four

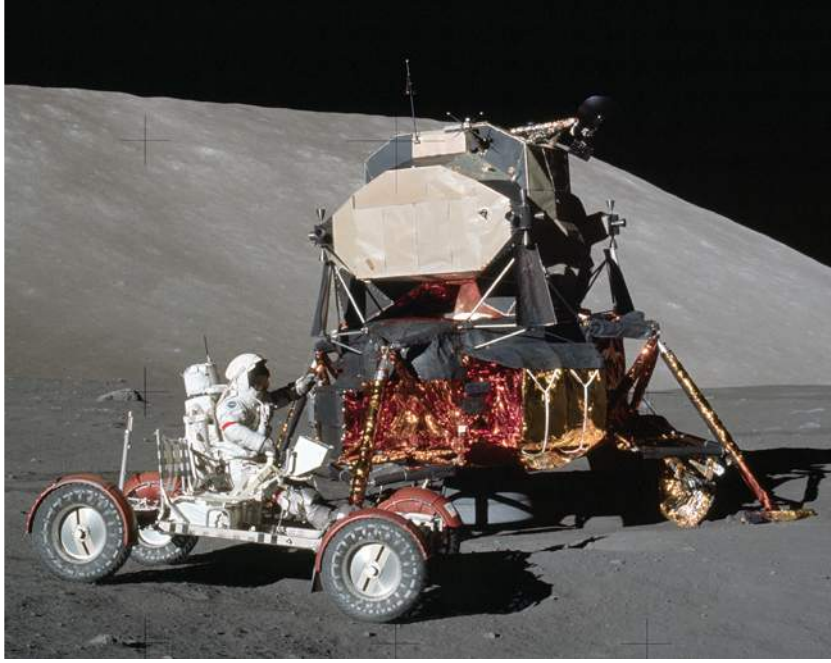
"We Shall Return"

Schmitt found, to his pleasure, that the pain in his forearms had disappeared overnight; after the mission, he would guess that his cardiovascular system was so much more efficient in one-sixth gravity that it literally 'cleansed' the muscles of lactic acid and other waste products, before they could cause any further damage.

There was also good news when they set foot on the surface. In preparing the lunar rover on the first day, Cernan had snagged the pull-out extension of one of the orange fenders with the handle of the geological hammer in shin pocket. He had repaired it using duct tape, but during the traverse it had become detached, and rained dust down on the vehicle.

The improvised new fender. *Photo: NASA*

John Young and the backup crew had crafted a repair during the night. Together with the engineers, they had folded four of the crew's geology maps into a rectangular shape, about the same size as a child's Halloween mask, and had taped them all together. Cernan and Schmitt were to do the same and then affix it to the remains of the fender



using a pair of clamps normally used to hold lamps in the cabin.

This improvisation worked, but it put them a full 80 minutes behind schedule. Nevertheless, Cernan would remember the hour-long drive to the base of the South Massif as one of the most exciting experiences from the entire mission, as he dodged craters and jerked the T-bar to negotiate each ridge and furrow.

On arriving at a broad trough-like depression at the base of the South Massif, they spent an hour sampling boulders which had tumbled down the flank of the 6,000-foot-high mountain. "In fact," wrote Cernan in his autobiography, *The Last Man on the Moon*, "we had tapped such a geological goldfield that Houston stretched our time there to the maximum and it was still frustrating to leave such a promising area."

By now, Cernan was far more than an aviator – if Schmitt had learned to fly a lunar lander, then he had become an exceptional field geologist – and they would find common ground in that there was never enough time to explore properly.

On the Moon, the demands of the clock were forever their enemy. In fact, the trough at the base of the massif was a fairly large crater – called Nansen in honour of the Norwegian explorer Fridtjof Nansen – which had been partially filled in by material which had slumped off the mountain.

For Schmitt, the landscape felt strangely familiar, reminding him of the Alpine valleys he had studied during his days at the University of Oslo.

Cernan and Schmitt were not allowed to drive further from Challenger than they would be able to walk back if the Rover conked out. This walk-back limit was extremely conservative, taking into account the possibility of damaged equipment, excessive oxygen usage and a multitude of other worries, to such an extent that both Cernan and Schmitt had tried to push it as far as they could. Here they hit a solid wall: the walk-back limit would not be compromised.

On the Moon, the demands of the clock were forever their enemy.

As Apollo 16 Moonwalker Charlie Duke once observed, amidst the grandeur and beauty and serenity of the Moon, it was all too easy to forget the cruel fact that there was a near-total vacuum just inches away from his flesh, and the slightest leak in the suit could spell instantaneous death.

For now, though, frustration was taking its toll. The men would certainly have benefited from longer at Nansen, but they had the craters Lara, Shorty and Camelot to explore. Approaching Lara, Schmitt described what he could see, chiefly for his colleagues in the science support room. While Cernan took a core sample, Schmitt did some solo-sampling and occasionally toppled into the soft lunar dust.

After a while, Parker nicknamed him 'Twinkletoes' and radioed that the switchboard at Mission Control was lighting up with calls from the Houston Ballet Foundation, requesting Schmitt's services, prompting the scientists to start referring to this crater as 'Ballet'.

It was their next stop, at Shorty Crater, that provided one of the real surprises of the mission.

More than a hundred metres wide, it was, radioed Schmitt, "a darker-rimmed crater…the inner wall is quite blocky…and the impression I have of the mounds in the bottom is that they look like slump masses that may have come off the side".

Orbital images acquired by Al Worden during Apollo 15 had shown clear evidence of a dark halo around Shorty, which contrasted with the lighter surroundings. It was suggestive of a volcanic explosion crater, and perhaps the source of the dark deposits elsewhere in the Taurus-Littrow region.

Cernan and Schmitt had only half an hour scheduled at this site. Soon after they began sampling, the geologist's boots scuffed away at the dust and, there before his very eyes, was the ubiquitous grey…and a slight tinge of orange.

Schmitt thought he was imagining it. Was his gold-tinted visor playing a trick on his eyes? He partly lifted the visor; it was still there. Orange soil. He called Cernan, who came bounding over. They confirmed it and jointly agreed that it looked like it had been oxidised, like the rust-coloured soil they had often seen in the desert during their expeditions with geology professor Lee Silver.

In the science support room, Silver himself was excited: this had to prove that Shorty was a volcanic vent. Cernan was excited: it was, he wrote, unexpected treasure, like a Spanish conquistador finding jungle gold.

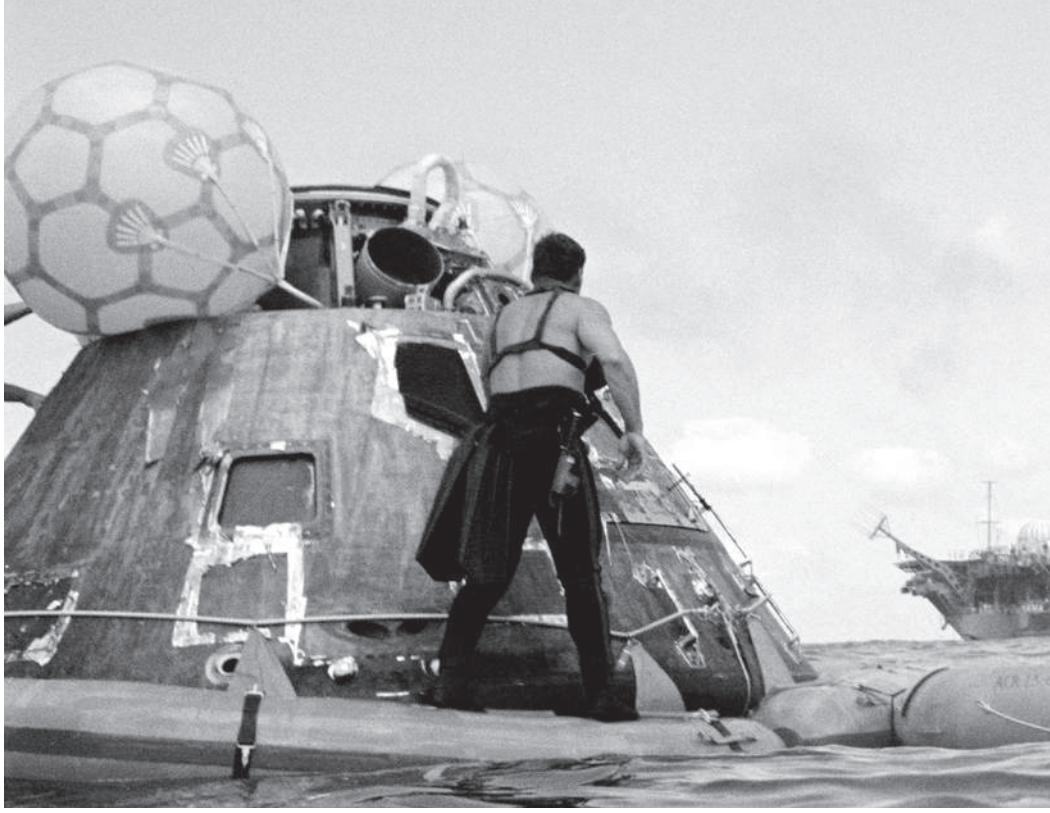
Meanwhile, Schmitt set to work digging a trench into the orange deposit in order to trace its extent, and found that it spread along an ellipse-shaped area which ran parallel to the rim of the crater.

In minutes, his opinion of Shortly had changed. When they arrived, he was convinced that it was an impact crater, but now – "if ever I saw a classic alteration halo around a volcanic crater, this is it!"

There was, however, no time to explore further. They had already spent ten minutes longer than planned at Nansen, and the walk-back limit precluded an extension at Shorty.

With only minutes available, Cernan drew his hammer and pounded a core tube into the orange soil at the base of the trench and both men were surprised that when they pulled it out, it was red for part of its length, but a couple of feet down it was a sort of purplish-grey, almost black.

Unfortunately for the volcanic theory of Shorty's origin, subsequent analysis would show that the orange material was composed of tiny beads of glass which had once been molten lava droplets spewed into the lunar sky in a fire fountain.



"The origin of the fountain," wrote Andrew Chaikin in his landmark book *A Man on the Moon*, "was a form of lava that contained dissolved volcanic gases. As it ascended from deep within the Moon to the surface, the effect was that of shaking up a bottle of soda and then uncapping it: the gas rapidly came out of solution, propelling molten rock high into the lunar sky.

Just as water pressure in a decorative fountain causes the liquid to break up into droplets, this so-called 'fire fountain' was composed of an intensely hot spray. In the weak gravity, the droplets arced hundreds or perhaps thousands of feet through the vacuum.

During their flight, they cooled into tiny glass spheres, which rained down on the valley of Taurus-Littrow." The beads derived their colour from the specific chemical composition of the lava – as indeed did the green beads recovered by Apollo 15. The dark soils of Taurus-Littrow would prove to be chemically identical to the orange stuff, the difference being that if the lava cooled rapidly it formed glass and if it cooled more slowly it produced dark crystals.

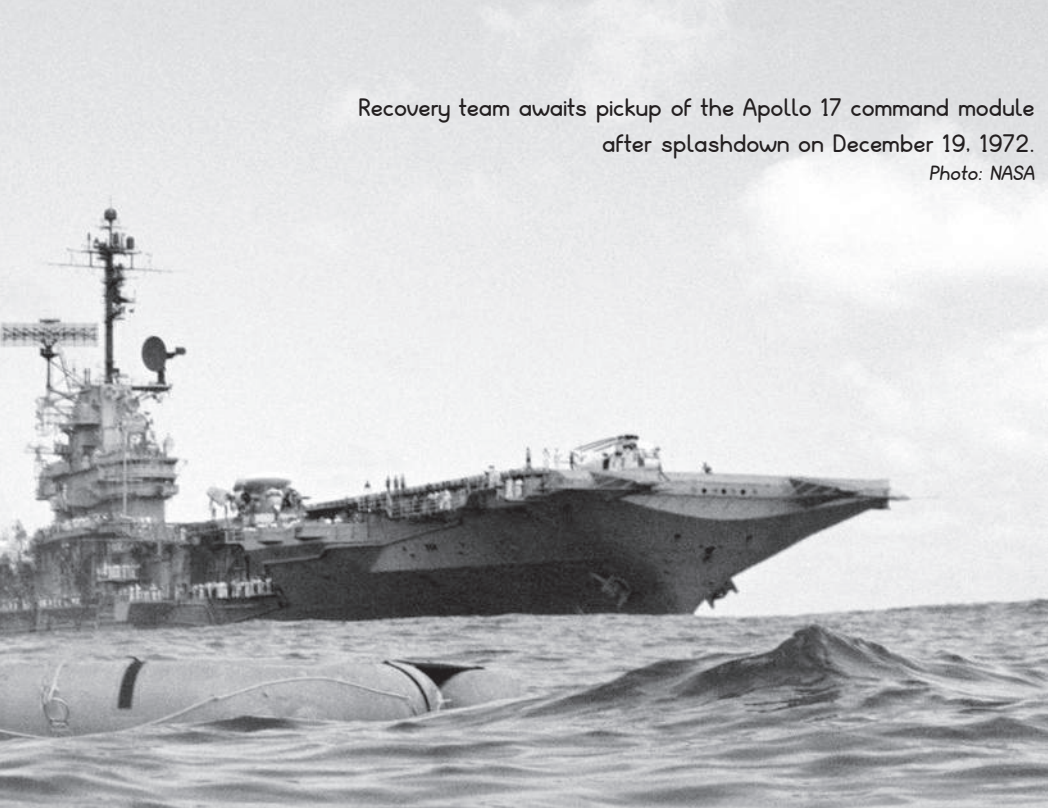
In conclusion, wrote Chaikin, both the orange soil and the dark stuff on the valley floor were evidence of volcanism, but the fire fountains had not occurred recently: in fact, they were around three and a half billion years old. The impact some 19 million years ago which created Shorty also excavated the buried materials to the surface ready for an astronaut nicknamed Twinkletoes to sample them.

Only one more period on the Moon's surface awaited them. On the afternoon of 13 December 1972, a little under seven days since launching from Florida, Cernan and Schmitt were outside for the third time.

Before launch, Schmitt – who had examined almost every aspect of the J-series space suits and their capabilities – had lobbied hard to get a fourth EVA tacked onto the mission, but to no avail: the conservative managers were aware that any emergency might leave them dangerously close to their water and battery reserves.

Cernan, too, was convinced that it could be done, but ultimately bowed to the judgement of programme manager Owen Morris.

The two men drove north past Sherlock Crater, swung right at Turning Point Rock and then across the lower flank of the North Massif. Orbital photographs had shown a



Recovery team awaits pickup of the Apollo 17 command module after splashdown on December 19, 1972.
Photo: NASA

large, dark-hued boulder, trailed by a five-hundred-metre furrow down the hillside. As they neared the boulder, Cernan and Schmitt could now see that it had broken into five fragments as it came to rest.

Schmitt was in his element, making a clear and decisive field study of the boulder in an effort to piece together its history, whilst Cernan huffed and puffed upslope to take a series of panoramic images of the geologist at work. One of these pictures is featured on the front cover of this book.

By the time that Cernan and Schmitt had completed their final sampling stop at the Sculptured Hills, they had effectively explored Taurus-Littrow from one end of the valley to the other and with three extravehicular sessions in excess of seven hours apiece, they had easily amassed more time on the surface than any other crew.

They had driven some 18 miles in the rover – whose makeshift fender finally snapped off during the ride back towards Challenger – and their 75 hours on the Moon were drawing inexorably to a close.

Both were exhausted, grimy and sore in their arms and hands, but their suits – those remarkable miniature spacecraft, upon which their lives so depended – had come through with flying colours.

> "I believe history will record that America's challenge of today has forged man's destiny of tomorrow."
>
> – *Gene Cernan*

The glory of Apollo was ending and Cernan had known for some time that he would be the last man on the Moon for many years to come.

Such thoughts were clearly on his mind when, shortly after 12:30 am EST on 14 December 1972, he took his final steps on the surface of a world other than that of his birth and heritage. He turned for one last look at the stark landscape – the Sculptured Hills, the North and South Massifs, the thousands of craters, the dark sky and the Earth hanging silently above – and suddenly found the words that he wanted to say.

More than three years earlier, Neil Armstrong's first words were uttered in triumph; now Cernan's last words were uttered with undisguised angst.

"Bob," he radioed to the ever-present Capcom Bob Parker in Mission Control, "this is Gene. As I take these last steps from the surface, back home for some time to come, but we believe not too long into the future, I believe history will record that America's challenge of today has forged man's destiny of tomorrow…And as we leave the Moon at Taurus-Littrow, we leave as we came and, God willing, as we shall return, with peace and hope for all mankind. Godspeed the crew of Apollo 17."

Those resonating words – spoken by a man with vision and passion and conviction and patriotism and childlike excitement for the thrill of adventure and discovery – continue to haunt us, for 40 years later we are still waiting.

Cernan believed history would record that America's achievement had forged man's future destiny, and in a sense, it did, and it continues to drive our species forward as an example of our ingenuity and ability to overcome the most immense obstacles.

However, the fact remains that the most promising endeavour in our history, whilst expensive, was abandoned in its prime.

As well as recording the greatest example of risk-and-reward ever undertaken, history also recorded our species losing its nerve.

"History," Apollo 17 backup crewman Stu Roosa once said, "will not be kind to us, because we were stupid."

For now, we have only the images and the newsreel film and the memories to remind us of a golden age before many of us – including this author – were even born.

And we have Gene Cernan's priceless last words.

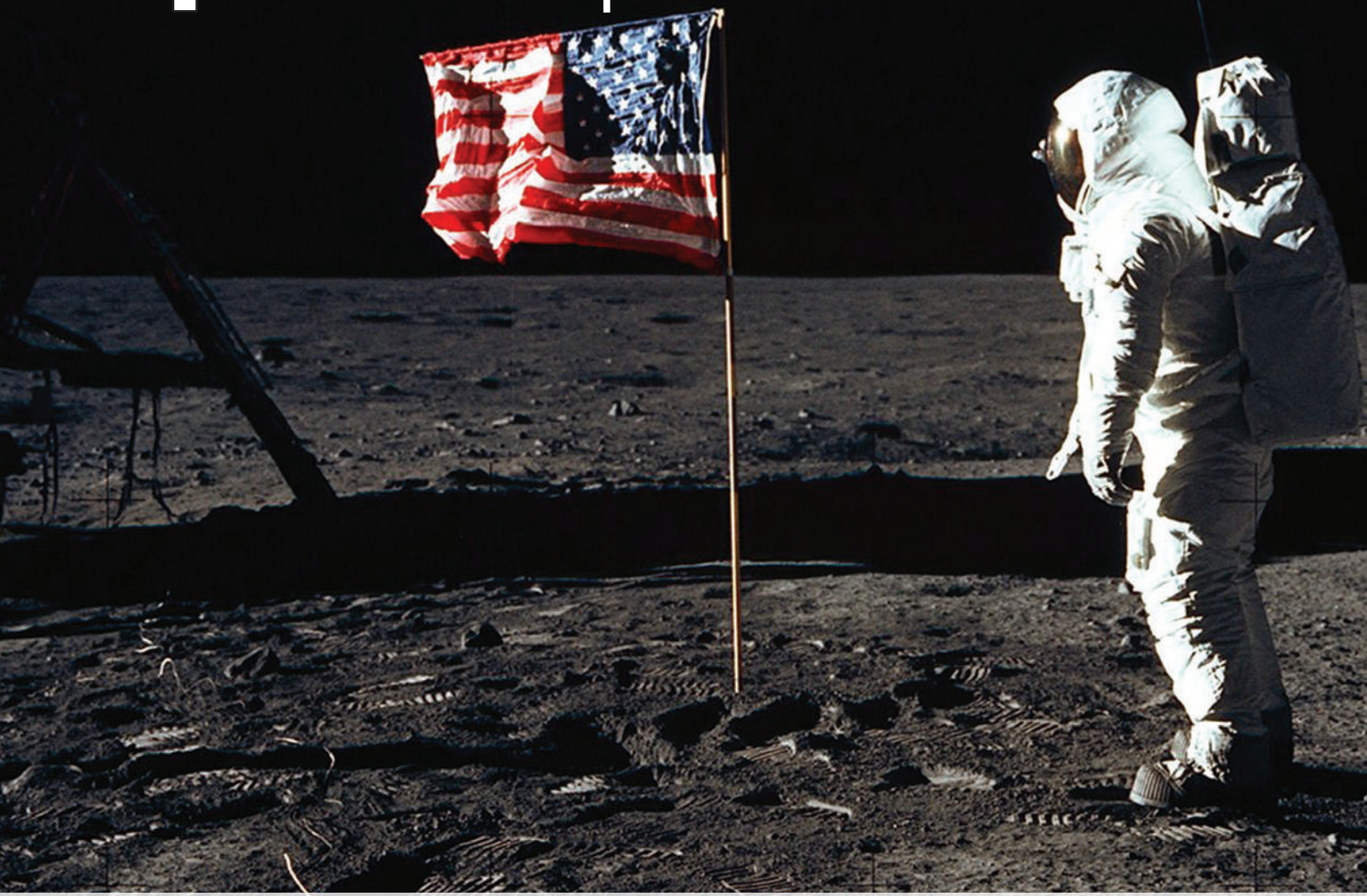
God willing...

We shall return...

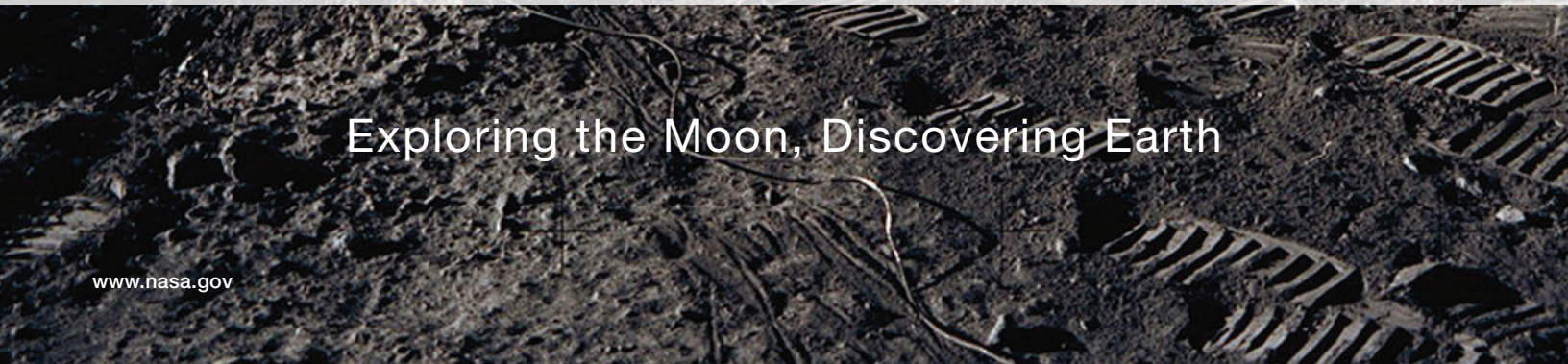
Someday.

National Aeronautics and Space Administration

Apollo Spinoffs



With the success of the Apollo program, NASA delivered great progress in the fields of rocketry and aeronautics, as well as the fields of civil, mechanical, and electrical engineering. Lesser known accomplishments are some of the many spinoffs that came from the Apollo program—partnerships created between NASA and industry to commercialize the technologies developed for the historic missions to the Moon. Find more Apollo spinoffs at **spinoff.nasa.gov**.



Exploring the Moon, Discovering Earth

www.nasa.gov

Freeze-Dried Foods Preserve Nutrients, Increase Shelf Life

Freeze-dried food solved the problem of what to feed an astronaut on the long-duration Apollo missions. Freeze drying foods preserves nutritional value and taste, while also reducing weight and increasing shelf life.

Cooling Suits Provide Comfort

Cool suits, which kept Apollo astronauts comfortable during moon walks, are today worn by race car drivers, nuclear reactor technicians, shipyard workers, people with multiple sclerosis and children with a congenital disorder known as hypohidrotic ectodermal dysplasia, which restricts the body's ability to cool itself.

Recycling Fluids for Space Missions Simplifies Kidney Dialysis

Special kidney dialysis machines were created as a result of a NASA-developed chemical process that removes toxic waste from used dialysis fluid. The process saves electricity and eliminates the need for a continuous water supply, granting the patient greater freedom.

Insulation Protects Alaskan Pipeline

Metal-bonded polyurethane foam insulation developed for protecting Apollo-era spacecraft was also applied to the Alaskan pipeline, where its temperature controlling properties were in high demand. In order to maintain its fluidity, the oil needs to be kept at relatively high temperatures (180 °F), a tall order in the Arctic. The NASA-derived insulation solved this problem.

Green Buildings Employ Space Suit Textiles

The same fabric used in Apollo-era space suits has been spun off into a cost-effective, environmentally-friendly building material. Used on structures around the world, the Teflon-coated fiberglass strands create a permanent, tent-like roof. Less expensive than conventional roofing materials, the durable white fabric allows natural light to shine through, saving a significant amount of energy.

Astronaut Conditioning Equipment Keeps People Fit

A cardiovascular conditioner developed for astronauts in space led to the invention of a physical therapy and athletic development machine used by football teams, sports clinics, and medical rehabilitation centers.

Flame-Resistant Textiles Safeguard Firefighters, Soldiers

After a fire on the Apollo launch pad which resulted in the death of three astronauts, NASA worked with private industry to develop a line of fire-resistant textiles for use in space suits and vehicles. These materials are now used in numerous firefighting, military, motor sports, and other applications.

We came all this way to explore the Moon, and the most important thing is that we discovered the Earth.

— William Anders, Lunar Module Pilot, Apollo 8

We Continue to See the Benefits of the Apollo Program Today.

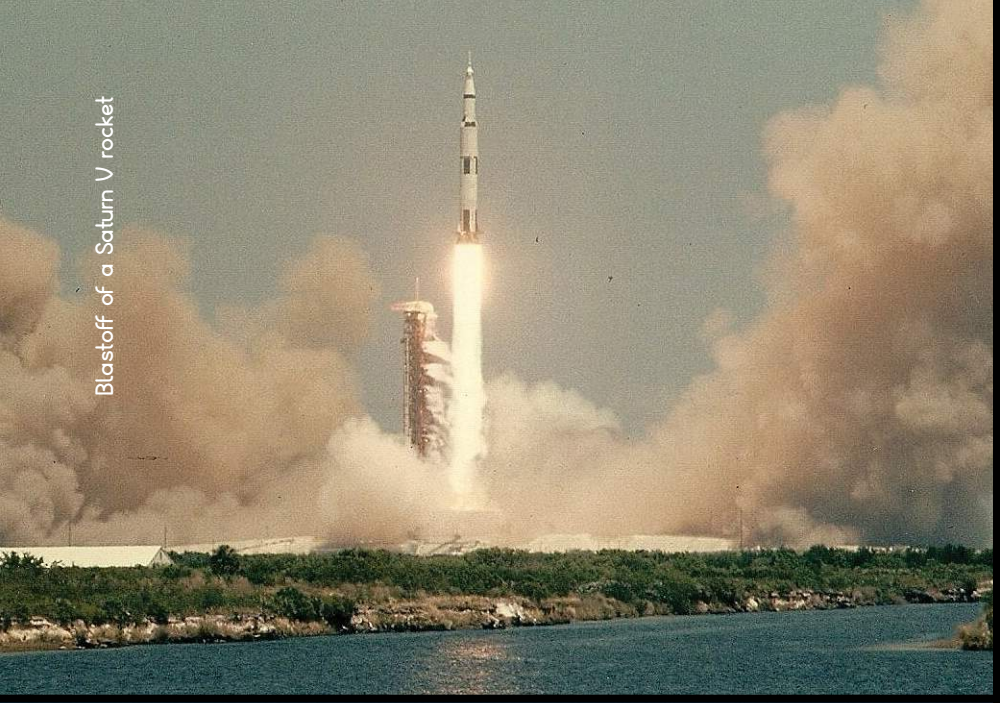
Not since Apollo have people travelled beyond low-Earth orbit or set foot on another celestial body. The challenge that was Apollo is still as great today as it was then, and the program heralded significant technological achievements.

NP-2009-06-590-HQ

Apollo Life Support Systems Filter Water

Water purification technology used on the Apollo spacecraft is now employed in several spinoff applications to kill bacteria, viruses and algae in community water supply systems and cooling towers. Filters mounted on faucets reduce lead in water supplies.

Apollo Spinoffs



Blastoff of a Saturn V rocket

Columbia arrives atop the SCA for the first time at KSC

Launch of SpaceX's Falcon 9 rocket

SPACEX ■ DELTA ■ SPACE SHUTTLE ■ ATLAS ■ SATURN/APOLLO

Photos by Julian Leek
Story by Chase Clark

EAGLE'S EYE VIEW OF SPACE COAST

Julian Leek is photographing key moments of NASA history

Julian sits on Endeavour's flight deck

It may seem like nothing more than a tall tale, to hear that after arriving at the Space Coast in the last 1960s, a teenager from England soon would be riding atop the launch tower for a Saturn V as it rolled out to the launch pad. But in this case, it is the real life story of photographer Julian Leek, a man who has been recording the history of America's space program from the vast wilderness of John F. Kennedy Space Center and Cape Canaveral Air Force Station since the launch of Apollo 7 in 1968.

Leek was born in a small country village in southern England, but followed his mother to the United States in 1967. She was already in the country promoting one of her books with TV, radio, talks shows and special events.

"My mother ended up staying & brought me over from the UK," said Leek "As for the Space Coast, one of her friends brought a Chinese junk (boat) from China, a real one, and had it shipped to America. They headed south from Boston and ended up at the Indian Harbor Pines Marina near Patrick Air Force Base. She made phone calls north to say they had just found paradise. The secret was out!"

With all the traveling across America that Leek was doing, a friend had decided to give him a Nikormat camera to document his journeys. Leek started photographing "everything." Combine that with the fact that a friend of the family was a member of the Air Force running the protocol office at PAFB and made certain that he always had passes to watch the rocket launches, and it is little wonder that he quickly became enamored with photographing the launches and everything to do with manned spaceflight.

"I went out to a launch and was hooked right away," said Leek, who would go on to be hired as a stringer covering the Space Coast for the *Miami Herald* newspaper. His work has appeared in publications all across the globe and on the internet.

From Apollo 11 all the way through Apollo 17, Skylab and the Apollo-Soyuz Test Program, he was right there in the midst of the action shooting photographs. Thousands of rolls of black and white and color film documenting perhaps the most adventurous undertaking of all time. The memories are many, but he does have a few favorites.

"By far seeing Apollo 11 take off for the moon," he exclaimed. "Riding out on the top of Apollo 16 as it traveled to the pad was an 'E' ticket. Looking down from the gantry while moving on the crawler way to the pad is a photo opp that not many people have had."

When Space Shuttle Enterprise, a prototype, arrived to prepare for the first launch of the Space Shuttle program in 1981, Leek was there once again with his camera, experiencing "the thrill of being on the edge of the VAB roof as history passes below." And when the program finished out its 30-year run with three launches in 2011, he was still there, although the film cameras had given way to a modern digital SLR camera. He received the rare opportunity to venture inside Space Shuttle Endeavour and, via AmericaSpace, followed the orbiter on her final journey "being on the streets with the people of Los Angeles day and night seeing the look of pride on their faces as 'their' shuttle passed by."

Whenever there is a launch of any rocket, whether it be Atlas, Delta, Falcon, SLS or another future space vehicle, the odds are that if you look around, you will see him out there with his camera to tell the story with each and every photo he takes.

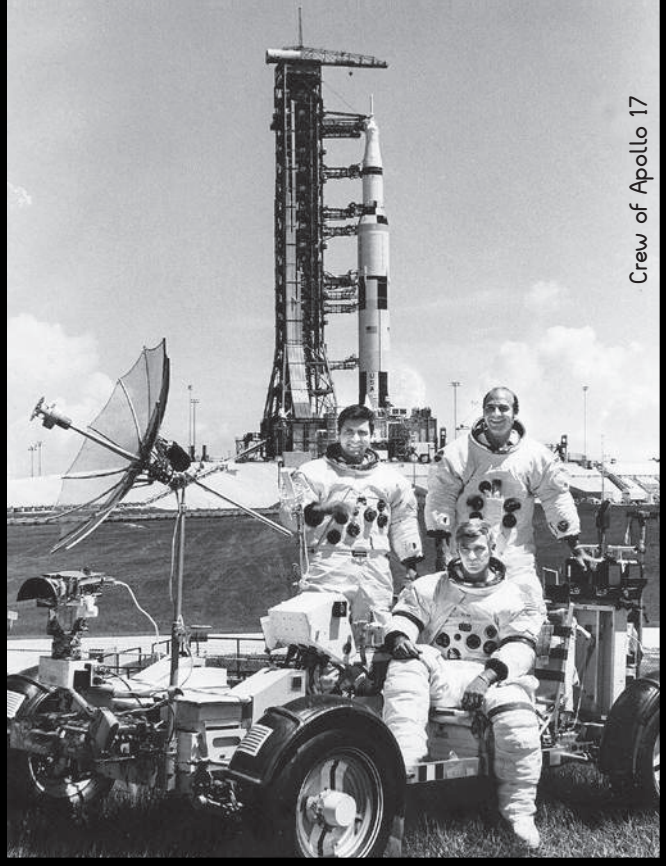
Endeavour moves slowly through streets of Los Angeles

Saturn 1B stands ready at Pad 39B

Hitching a ride high above Apollo 16's rocket

Julian meets Apollo 7's Walter Cunningham *Photo: MLOK*

Enterprise and MLP as seen from atop VAB



Crew of Apollo 17

Apollo 17 liftoff

Endeavour before STS-134 launch

Saturn V awaits last Moon launch

Boarding the Astrovan for launch of Apollo 14

Photography by Julian Leek

Atlantis atop Pad 39A for STS-135

Emily Nelson working to keep astros safe

Interview by Sherry Valare

At all times, astronauts live aboard the International Space Station (ISS). They carry out their daily activities working in a zero gravity habitat orbiting Earth, while their lives are in the hands of a ground crew hundreds of miles below them back on the ground. These "professional problem solvers" monitor everything happening inside and outside of the walls protecting the astronauts, 24 hours a day, ready to take action on a moment's notice.

Emily Nelson is a flight director out of NASA's Johnson Space Center in Houston, Texas. She is one of several flight directors in charge of the different duties crucial to the success of each mission. Every day she runs through a whirlwind of job duties that all lead to one ultimate goal – to ensure the safety of the crew and the success of their mission.

She painted a picture of her day-to-day activities for me with a level of enthusiasm that clearly indicated the passion she possesses for her role.

After learning the characteristics that a strong candidate for flight director must have, I realized why she was one of the people NASA chose to fulfill this critical role.

Q: Tell me about your educational background and the path you took to become a Flight Director:

Nelson: "I graduated from University of Texas at Austin, with a Bachelor of Science in Mechanical Engineering, and went straight to work at NASA's Johnson Space Center. I have been a flight director for five and a half years. I started as a Thermal Systems Tech Controller, and I stayed in that position until I became a Flight Director."

Q: What are the general requirements and duties of your position? What exactly does a Flight Director do?

Nelson: "There are a number of us that manage the different aspects of space station operations. The duty that people are most familiar with is running the flight control team. They ensure the safety of the crew, vehicle, and mission objectives. Everything else stems from that – ensuring safety. There ends up being a number of smaller tasks we oversee and do, and in practice, we've got a number of us that are working on missions that will occur in the future. We are either prepping for future missions, or overseeing mission control.

One of us will monitor mission control at all times for space station operations. That is an around the clock job because there are always crew members living on the International Space Station, therefore a flight director is always responsible for the mission being executed. For example, I was the flight director in charge of Suni William's crew, which included Yuri Malenchenko, and Aki Hoshide.

The flight directors cycle through different responsibilities – while Suni was commander, I was doing all of the meetings and planning as lead flight director, but now that she and her crew are safely back on the ground, another flight director will take over that role for as long as the next commander is in charge of International Space Station. So I will go back to doing other stuff – for example, executing the team's plans. It works best when we have each done the different jobs, so that we can gain the experience."

Q: What is a typical day like in your position?

Nelson: "While you are the person responsible overall for the current mission, there is a much wider community of people outside of operations involved in supporting spaceflight; these people meet every single day. The lead flight director (my position during Suni's mission) is in these meetings as well, to keep everyone on the same page as to what is happening on the vehicle and the mission progress. The space station has been in orbit for tens of years, if someone has an idea or an issue, then discussions are held in these forums.

Continued on page 42

ISS flight director Emily Nelson monitors data at her console in the space station flight control room in the Mission Control Center at NASA's Johnson Space Center during STS-132/ULF-4 mission flight day five activities.

Photo: NASA/JSC

NELSON continued from page 40

There are several other organizations that participate in these meetings. There is an engineer doing "Apollo 13 style operations" – watching data coming from the vehicle and responding the data.

You know the scene in Apollo 13 where they bring in a team of people to fix things? Well, those people make up the Engineering Support Team. They work in the M.E.R. – Mission Evaluation Room – directly under the space station program.

They have all the historical data and access to vendors and companies around the country that produce hardware. To figure out problems, they can contact the vendors and get the details they need to solve a problem; we work with them on a regular basis.

Next, there is a management team who is responsible for deciding what the mission will be, what will be accomplished and how the priorities will be organized. Prioritizing is a necessity because the lab is an ongoing operation that has been running for years. Once these plans are laid out, the operations team will execute them based on the priorities set, doing what fits in the time allowed.

In addition to this, we have a safety organization representative from the astronaut office, as well as analysis teams running computer simulations of a variety of environments the International Space Station could possibly fly into, so we can fully understand the constraints on various operations."

Q: Do you interact directly with our international partners who have crew on the International Space Station?

Nelson: "The meetings I just described are only made up of NASA staff meeting a few times a week. In addition to that, we have an international team that meets twice a week to make formal agreements and have discussions that are important to the entire partnership. There are representatives from the Japanese Aerospace Exploration Agency (JAXA), European Space Agency (ESA), Canadian Space Agency (CSA), Russian Space Agency (RSA) and NASA, to name a few.

Flight director Emily Nelson

Photo: NASA/JSC

On any given day we will have one of these meetings in the morning. In some cases, you have translation involved; a big group of international partners will break up to talk to each other individually beforehand to simplify the meeting."

Q: What is it like to be a woman in a field like this? Are you treated differently?

Nelson: "Honestly, I do not notice it a whole lot. I was at a Science and Math magnet for high school. By the time I was out of engineering school, I was already used to working in a male dominated field. It might even be hard to work in a female dominated field because I am used to this now.

There are probably more women in mission control than most people would assume. I was giving a friend a tour a few years ago, and that day, looking at mission control, she noticed it was a room filled with women. It is not unusual today due to the work of previous generations.

Shannon Lucid, who was one of the most amazing astronauts ever, in my opinion, worked as a Capsule Communicator (CAPCOM) until her retirement last year. It was a great privilege to work with her in mission control.

When things were quiet, she would tell me stories – about how when she was a teenager, women had to have permission from their father to take flying lessons. Her generation paved the way for future women in this field."

Q: What kind of advice would you give to the classic "underdog" student – the one that doesn't have perfect grades, or thinks that they could never achieve this kind of position?

Nelson: "First of all, do not ever let anybody tell you what you cannot do. Where I am concerned, math is just a language, all you have to do is learn it. Some people are not great at learning languages, but once you have learned how to add, it is just math from there on out and it is just a matter of time until you figure it out and learn to do it better.

Obviously, math and science are important. I had to have an engineering degree for this position because I have to understand those principles behind the decisions I make. It is important that I understand how the world works to know what technical solution to solve a problem with.

In operations, I have never designed something or never drawn up new plans. I have to figure out how to work with what we have got, and that is just problem solving. Problem solving is everywhere, and that is what engineering really is – learning how to solve the problems we encounter around us.

To do the operations job well, you have to have good common sense, be observant of the world around you, and see solutions that are not obvious.

It is not normal to have advanced degrees in this field, you do not need years in a lab studying, or working on a Masters or Ph.D – we need people who are creative and can

ABOVE: ISS flight directors Holly Ridings (seated) and Emily Nelson monitor data at their console in the space station flight control room in the Mission Control Center at NASA's Johnson Space Center.

LEFT: The members of the STS-132/ULF-4 ISS Orbit 2 flight control team pose for a group portrait in the space station flight control room. Flight director Emily Nelson holds the Expedition 23 mission logo.

Photos: NASA/JSC

find solutions that are not obvious.

Actually, it is frequently the people who had some trouble with academics who end up doing well in this job.

The thing that separates mission control engineers from others is the fact that in mission control, it is crucial that you communicate efficiently and effectively. You cannot be a bad communicator. You have to say what you mean in as few words as possible because you do not have a lot of time to work with. Because of this, you cannot just blow off English in school.

We have people who have to go to classes to pick that up because they did not learn it in school. Whether it is presenting a complicated technical question to management about how to do something, or explaining the necessity for an action to a flight director in three minutes or less because that is all the time you have to move, these are essential skills.

Yes, math and science are important to know, but being able to talk about math and science is equally important."

Q: Do you have final thoughts to share?

Nelson: "One thing I have noticed in my interactions with anyone working for NASA, it is not necessarily about the person with the best grades in being chosen for a position. It is more about you as a person, what you can contribute to the table -- how you can be the difference."

As the conversation ended, I let her know that the work they do is appreciated, and that she is truly an inspiration. Because let's face it, for anyone who has ever seen the International Space Station pass over them in the sky like a traveling star, it is natural to wonder who is watching over them, while they are up there watching over us.

Dubbed 'Apollo on steroids'

NASA developing rocket to take us beyond LEO again

By Montserrat Cordero

What is the Space Launch System? It's NASA's plan for a next generation space exploration vehicle, and it is built like a big puzzle by putting together the best of both the Saturn V that took men to the Moon and the Space Shuttle that for 30 years took us to low Earth orbit. Here's a look at it.

Let's begin with the Space Shuttle. It had two huge rockets attached to its sides, we can save those SRBs (Solid Rocket Boosters), they gave the Shuttle much of the power it needed to leave the Earth behind. The Space Transportation System used liquid oxygen and hydrogen for combustion through its RS-25 engines, better known as SSMEs or Space Shuttle Main Engines, let's get rid of that name but keep the engines.

How about the Saturn V? The whole command and service module idea worked pretty well, but let's expand it to fit four people instead of three. This development is already in the making with the Multi-Purpose Crew Vehicle or Orion. Since we're going to have people on board, a launch abort system like the one used on the Saturn V seems like a smart idea. The Saturn V used J-2 engines in the second stage. Perhaps we can reuse those.

Now what do we get if we put all of these parts together? A vehicle with the most lift capability of any past, present or planned vehicle. The SLS comes in a 70 metric ton and a 130 metric ton configurations The 70 metric ton rocket will use four or five RS-25 engines and two SRBs, along with the Orion crew capsule. The 130 ton configuration is similar but it adds an upper stage that uses two J-2X engines, which are a more efficient and simpler to build version of Apollo's J-2 engines. These were originally developed for the now defunct Constellation programm, but are now being repurposed for the SLS.

The SLS was designed to be flexible. No one is certain of what will be NASA's next move. There are plans out there for Mars, the Moon and even asteroids. The SLS is flexible enough to fit the needs for any of those missions. If needed, SLS could even travel to the ISS just like the Space Shuttle did.

Development of the SLS is an ongoing process. NASA has already scheduled Exploration Mission 1, its first launch for 2017. This mission would carry an unmanned Orion capsule, with the purpose of testing the integration and general performance of the spacecraft, before adding humans to the equation. Exploration Mission 2 is planned for 2021. This one would be a manned launch on a lunar orbit flyby with a crew of up to four on board the Orion capsule.

The Space Launch System is the point where NASA's history and future meet. With proven hardware and new technologies it plans to take us further that we have ever been before, both in distance and in knowledge. There are still a lot of uncertainties, but there is also time to figure them out. We are at an exciting moment in the development of this spacecraft, but we have to wait and see.

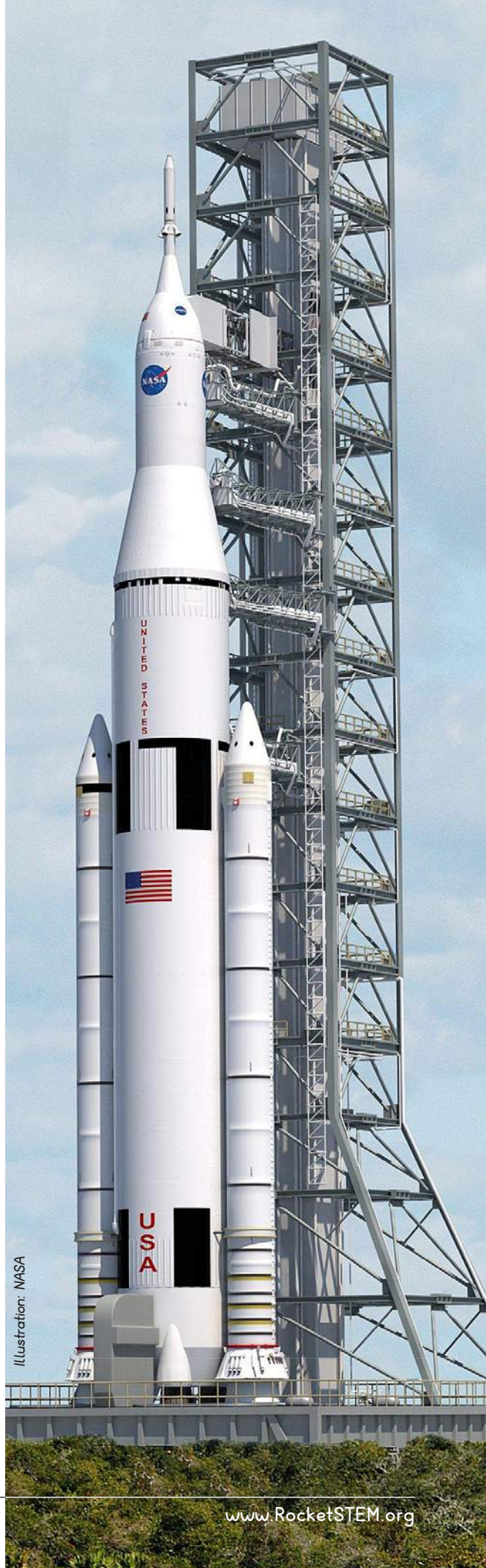


Illustration: NASA

Orion advancing toward 2014 test flight

By Ken Kremer

NASA is making steady progress toward liftoff of the inaugural space-bound Orion crew capsule. The agency aims for a Florida blastoff of the uncrewed Exploration Flight Test-1 mission (EFT-1) - about 18 months from now - in September 2014 atop a Delta 4 Heavy Booster, NASA officials informed me. Orion will ultimately fly astronauts to deep space destinations including the Moon, asteroids and Mars.

I recently inspected the Orion during a visit to check the work in progress inside the cavernous manufacturing assembly facility in the Operations and Checkout Building (O & C) at the Kennedy Space Center (KSC).

Orion EFT–1 crew cabin and full scale mural showing Orion Crew Module atop Service Module inside the O & C Building at the Kennedy Space Center, Florida. *Photo: Ken Kremer*

A lot of hardware built by contractors and subcontractors from all across the U.S. is now arriving at KSC and being integrated with the EFT-1 crew module (CM), said Jules Schneider, Orion Project manager for Lockheed Martin at KSC.

"Everyone is very excited to be working on the Orion. We have a lot of work to do. It's a marathon not a sprint to build and test the vehicle," Schneider explained to me.

The bare bones, welded shell structure of the Orion crew cabin arrived at KSC in Florida from NASA's Michoud facility in New Orleans in June 2012. Since then, technicians from Lockheed and United Space Alliance (USA) have made noticeable progress preparing the craft.

Technicians were busily installing avionics, wiring, instrumentation and electrical components as the crew module was sitting inside the Structural Assembly Jig during my follow-up visit. The Jig has multiple degrees of freedom to move the capsule and enable assembly work.

"Our primary focus is finishing the structural assembly of the crew module," said Schneider. "Simultaneously the service module structural assembly is also ongoing. That includes all the mechanical assembly inside and out on the primary structure and all the secondary structure including the bracketry. We are putting in the windows and gussets, installing the forward bay structure leading to the crew tunnel, and the aft end CM to SM mechanism components. We are also installing secondary structures like mounting brackets for subsystem components like avionics boxes and thruster pods as parts roll in here."

"A major part of what we are doing right now is we are installing a lot of harnessing and test instrumentation including a lot of strain gauges, accelerometers, thermocouples and other gauges to give us data, since that's what this flight is all about - this is a test article for a test flight."

"There is a huge amount of electrical harnesses that have to be hooked up and installed and soldered to the different instruments. There is a lot of unique wiring for ground testing, flight testing and the harnesses that will be installed later along with the plumbing. We are still in a very early stage of assembly and it involves a lot of very fine work," Schneider elaborated. Ground test instrumentation and strain gauges are installed internally and externally to measure stress on the capsule.

Construction of the Orion service module is also moving along well inside the SM Assembly Jig at an adjacent work station. The SM engines will be mass simulators, not functional for the test flight.

The European Space Agency (ESA) has been assigned the task of building the fully functional SM to be launched in 2017 on NASA's new SLS rocket on a test flight to the Moon and back.

Over the next few months a great deal of work is planned. The next parachute drop test is set for February 2013. The heatshield skin and its skeleton were manufactured at a Lockheed facility in Denver, Colorado and being attached this month.

"In March 2013, we'll power up the crew module at Kennedy for the first time," Brandi Dean, a NASA Public Affairs Officer told me.

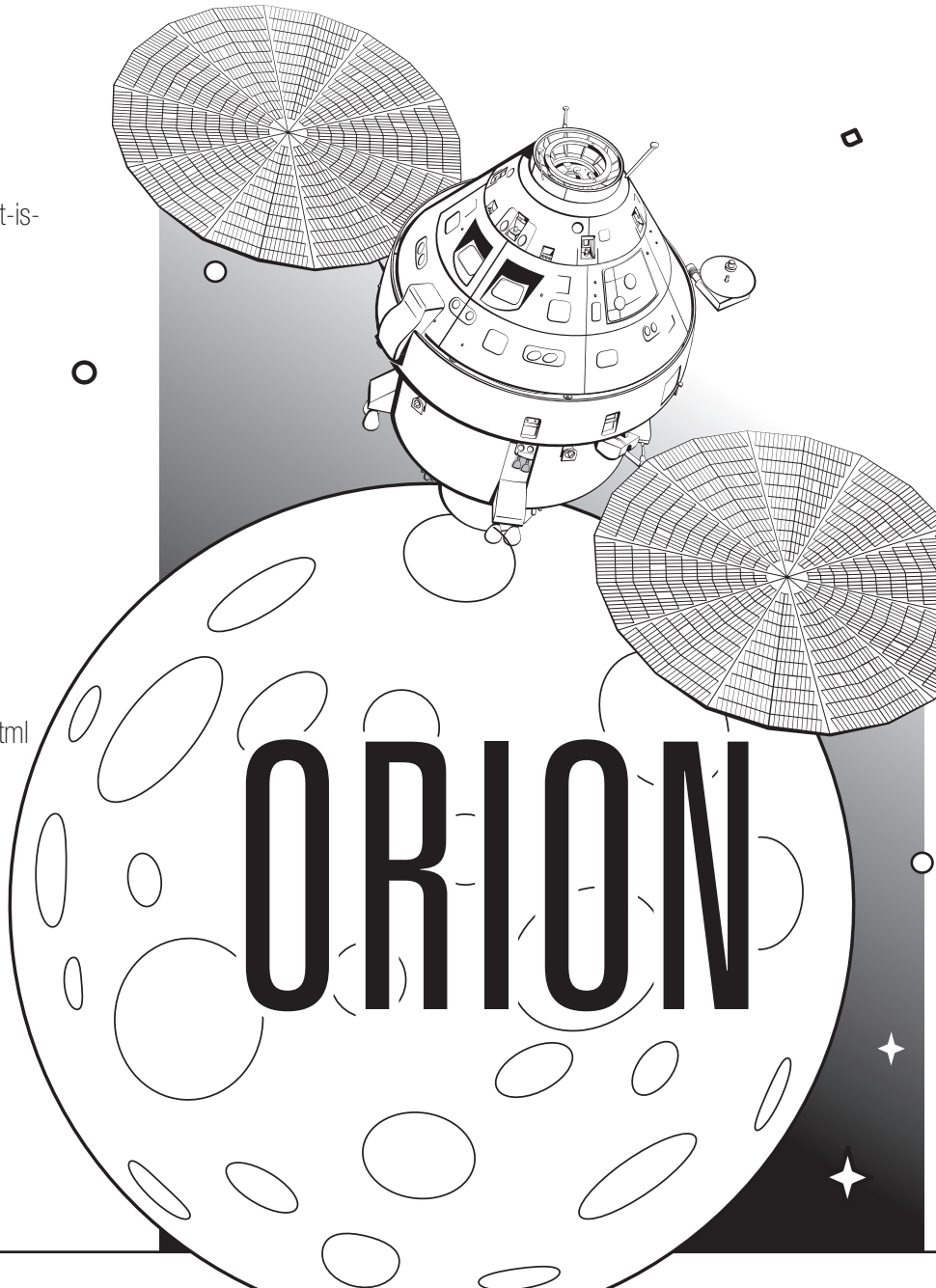
Orion will soar to space atop a mammoth Delta IV Heavy booster rocket from Launch Complex 37 at Cape Canaveral Air Force Station in Florida. Construction and assembly of the triple barreled Delta IV Heavy is the pacing item upon which the launch date hinges, NASA officials informed me.

"Following the EFT-1 flight, the Orion capsule will be refurbished and reflown for the high altitude abort test, according to the current plan which could change depending on many factors including the budget," explained Schneider.

Resources for students and educators of grades K-12

National Aeronautics and Space Administration

Let's Explore With



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www.nasa.gov/johnson

NASA Orion Spacecraft
www.nasa.gov/orion

NASA Space Launch System
www.nasa.gov/sls

NASA Ground Systems
www.nasa.gov/exploration/systems/ground/index.html

"What is Orion?" Education Page
www.nasa.gov/audience/forstudents/5-8/features/what-is-orion-58.html

NASA's "Beyond Earth"
www.nasa.gov/exploration/home/index.html

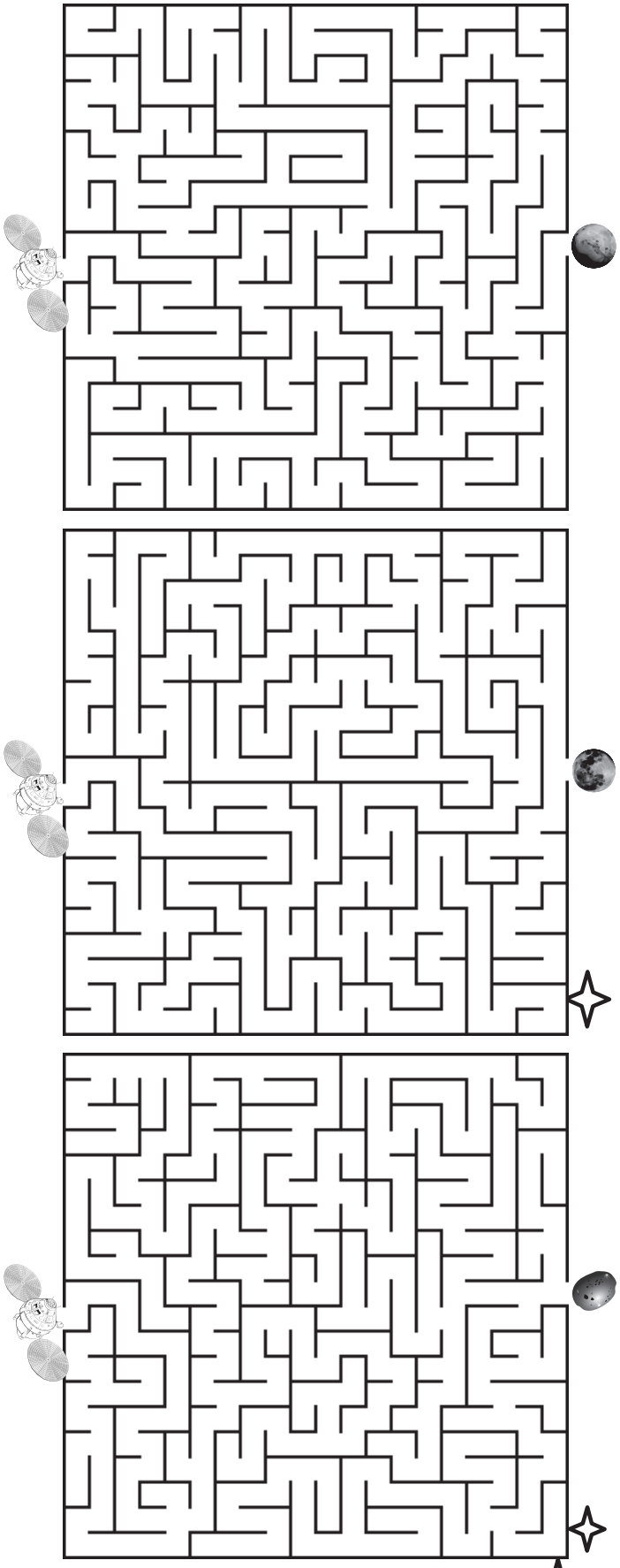
NASA's Education Home Page
www.education.nasa.gov

NASA Explorer Schools
www.explorerschools.nasa.gov

NASA Educator Resource Network
www.nasa.gov/audience/foreducators/k-4/learning/F_Educator_Resources_Center_Network.html

aMAZing Orion Destinations

Help Orion reach its three potential destinations – the moon, Mars and near-Earth asteroids.



Why Mars?

- Robotic and scientific robotic missions have shown that Mars has characteristics and a history similar to Earth's, including evidence of water. Humans can build upon this knowledge and look for signs of life and investigate Mars' geological evolution, resulting in research and methods that could be applied here on Earth.
- A mission to our nearest planetary neighbor provides the best opportunity to demonstrate that humans can live for extended, even permanent, stays beyond low Earth orbit. The technology and space systems required to transport and sustain explorers will drive innovation and encourage creative ways to address challenges.

Why the moon?

- The moon offers us a chance to look back at the history of the Earth and how it was formed. Because it has no atmosphere and has been virtually untouched, the moon serves as a history book of the early years of our own planet and our solar system.

Why asteroids?

Orion may travel to a near-Earth asteroid to explore the possibilities for resources that asteroids might hold.

- Near-Earth objects (NEOs) are comets and asteroids that have been nudged by the gravitational attraction of nearby planets into orbits that allow them to enter the Earth's neighborhood.
- As the primitive, leftover building blocks of the solar system formation process, comets and asteroids offer clues about the chemical mixture from which planets in our solar system formed billions of years ago.
- The raw materials found in asteroids could be used in developing the space structures and generating the rocket fuel that will be required to explore and colonize our solar system in the 21st century.

*Answers on back page.

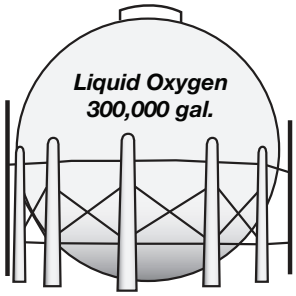
Fuel Up and Fly!

At Kennedy Space Center's launch site, Orion and the Space Launch System (SLS) are ready to blast off. Help the ground operations crew fill up for launch.

Fuel Fact: *Hydrogen can be found in large amounts in giant gas planets and stars.*

Fuel Fact: *Although oxygen gas is colorless, the liquid and solid forms of oxygen are blue.*

The SLS rocket holds 520,456 gallons of liquid hydrogen and 194,443 gallons of liquid oxygen. There are three tanks at the launch pad that hold 300,000 gallons of fuel each. Once the rocket is completely fueled, how much liquid hydrogen and oxygen will be left in each ground tank? Fill in the blanks. *Hint: You will need to totally empty one hydrogen tank before using the other.*



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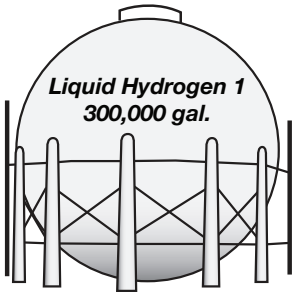

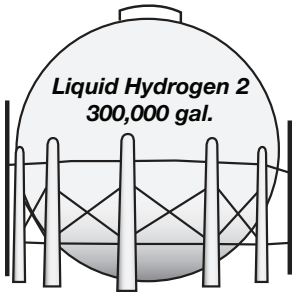

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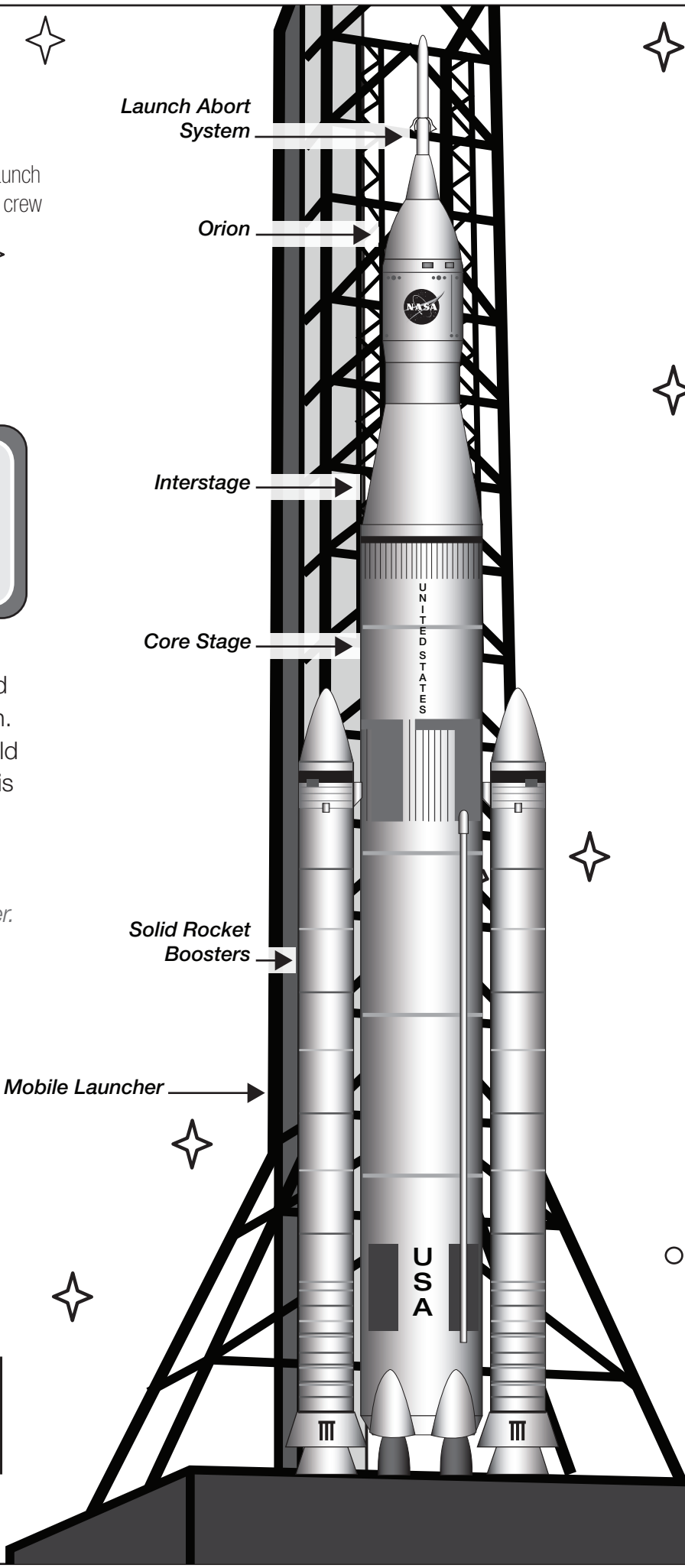


Learn about Orion and the Space Launch System (SLS)

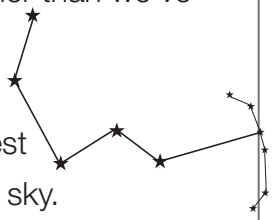
Fill in the blanks to learn about the Orion Spacecraft.

Word Bank

Earth	constellations	69,000 pounds
Exploration Mission 1	Mars	low Earth orbit
four	20,000 mph	2017
321	154,000	

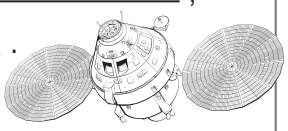
1. This new spacecraft will take us farther than we've gone before, including _____.

2. Orion is named after one of the largest _____ in the night sky.



3. Orion is being rigorously tested as engineers prepare it for a journey beyond _____ .

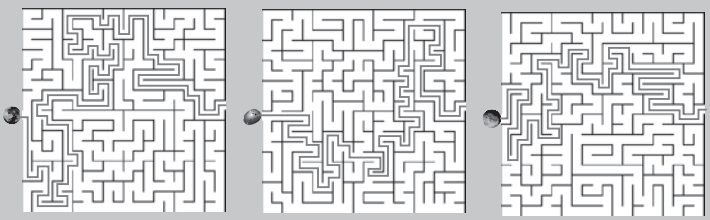
4. The first SLS mission called _____ , will occur in the year _____ .



5. The crew module can carry _____ astronauts.

6. The SLS will stand _____ feet tall and will carry _____ pounds of payload.

*** Answers**



Learn About Orion/SLS answer key

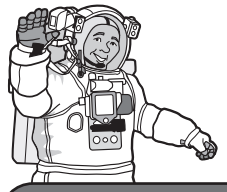
1. Mars
2. constellations
3. low Earth Orbit
4. Exploration Mission 1 and 2017
5. four
6. 321 and 154,000

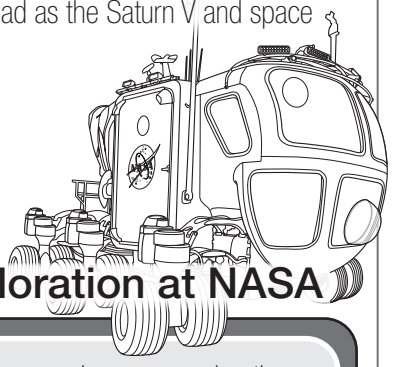
Fuel Up and Fly answer key:

Liquid Oxygen Tank: 105,557
Liquid Hydrogen Tank 1: 0
Liquid Hydrogen Tank 2: 79,544

Orion and SLS Fun Facts

- Each part of the Orion spacecraft has been tested by NASA engineers and scientists. The Launch Abort System was tested in New Mexico, the parachutes at the U.S. Army Yuma Proving Ground. All of these will play a role in the planned uncrewed orbital flight test of Orion in 2014.
- Orion will utilize advances in propulsion, communications, life support, structural design, navigation and power, drawing from the extensive spaceflight experience of NASA and its industry partners.
- The first Orion test flight will occur in 2014. The spacecraft will launch 3,000 miles into space in order to reach speeds of more than 20,000 mph.
- Orion will have the capability to carry crew members to destinations such as near-Earth asteroids, our own moon, the moons of Mars and eventually Mars itself.
- The SLS height is 321 feet, which is taller than the Statue of Liberty.
- The SLS will use proven hardware and cutting-edge tooling and manufacturing technology from the Space Shuttle Program.
- The SLS will stand atop a modified mobile launcher and will launch from the same pad as the Saturn V and space shuttles did.





Exploration at NASA

This is the beginning of a new era in space exploration. We are building the capabilities to send humans beyond low Earth orbit and to destinations such as Mars. Orion and SLS are at the core of NASA's human exploration plans. Other technologies include new spacesuits, advanced communications systems, advanced propulsion methods and more! The road ahead is challenging but this approach to space exploration puts us in a position to go where no human has gone before. To learn more about NASA's exploration missions, please visit: www.nasa.gov/exploration/home.

EP-2012-07-016-JSC

Starting in astronomy

monthly guide to stargazing for students

By Mike Barrett

Photos: NASA

Everyone at some time in their lives must have looked up at the stars in awe at the vastness of our home galaxy and the universe. This is the first step in your journey in the amazing world of astronomy.

I am writing this series of articles as I found it very difficult to work out what equipment I needed and more importantly what I could realistically expect to see. Starting from scratch I will take you on a magical journey into Astronomy avoiding some of the common pitfalls and issues faced by newcomers to the science.

When you look at all the images on the Internet and in magazines you see all these wonderful and colorful images of planets, stars, nebulas and galaxies and expect to be able to see these yourself. This is very unlikely to happen, but there a wealth of amazing things that you can achieve with just a little money and a lot of patience.

Now your first instinct may be to scan the Internet or local adverts to buy a telescope. Stop right there! This is the first mistake people make. I will cover buying your first telescope in a later article, but for now lets look at other Astronomy options available costing little to nothing which will get you started in the right direction.

terminology

As with most things in life there is a whole dictionary of terminology and TLAs (Three Letter Acronyms) to learn for astronomy. If you bear with me I will explain them as we come across them, and have a lookup table or panel with each article.

learning the stellar constellations

Indeed there is a lot you can do in astronomy on your own with no financial outlay whatsoever. Simply going to your local library and borrowing a book will help you to gaze into the skies and start learning the constellations. The constellations date from way back over 4,000 year ago. Our ancient relations looked up in the night sky and visualized pattens by drawing lines between prominent stars and associating animals, mythical figures or common artefacts with them.

Learning the constellations is a great grounding for your introduction into Astronomy. With this knowledge you can navigate both the celestial and terrestrial domains. More importantly it will provide the basic knowledge for finding the various wonders of the heavens above. With 88 constellations there are lots to learn. Don't worry I only know a few but I am learning all the time. Learning to distinguish some of the major constellations will get you on your way and the others will fall into place over time.

join your local astronomy society

The next thing of value that you can do, and possibly the best possible advice that can be given to a newcomer, is to get in touch with your local Astronomy Society. If you can find an active society you will find that there will be people of all different abilities, and interests, most of who will be happy to share their experiences with you.

Societies hold regular observation evenings and open evenings when members and the general public have access to the various telescopes, binoculars and other equipment. This will allow you to both talk to someone who has experience and also to try some of the equipment out as well.

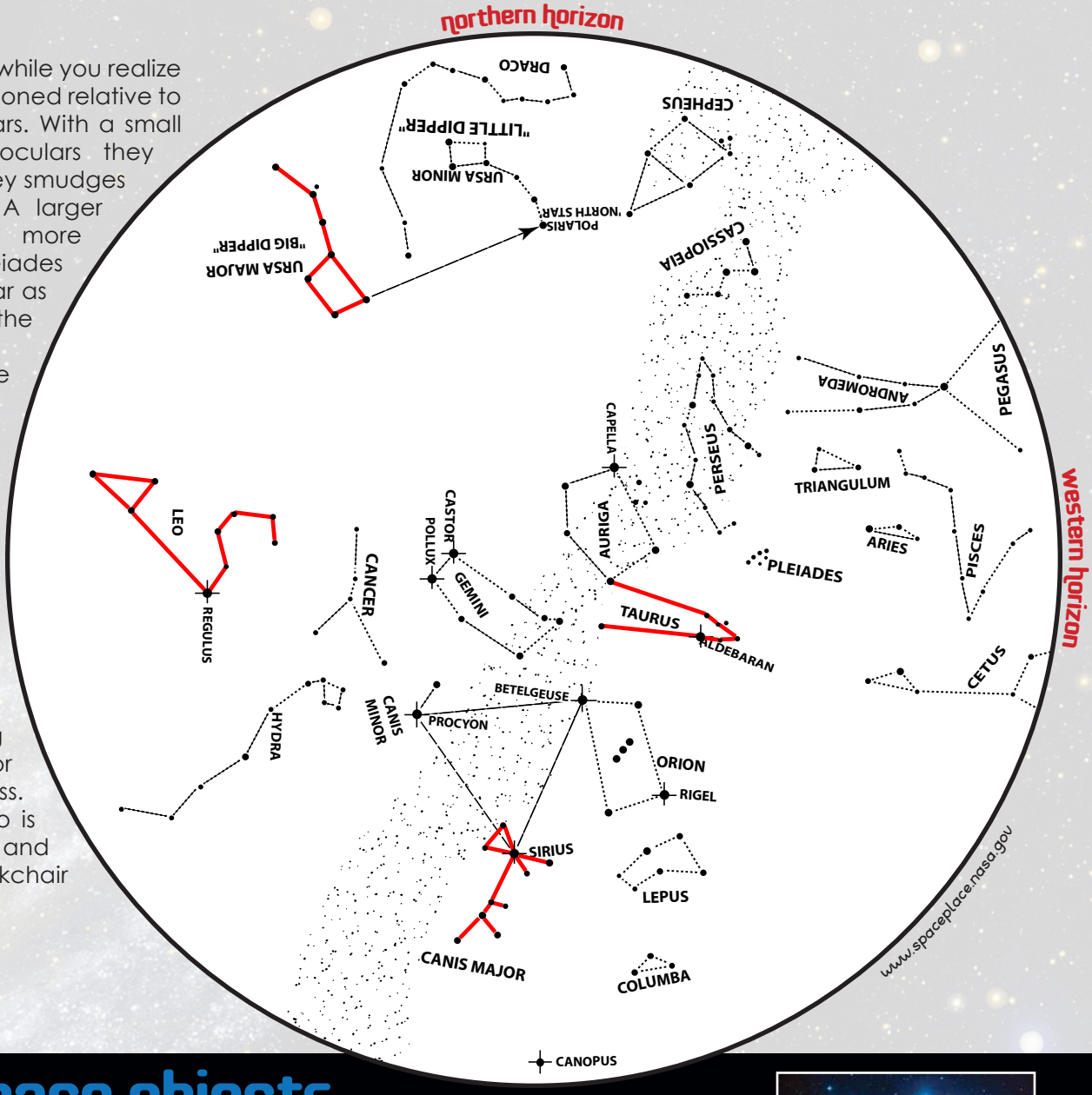
naked eye observing

There are a number of things that can be observed with the naked eye. The more you learn the more you can see. That of course is not strictly true, the more you learn the more you realize what you are seeing. First start with the brightest things in the sky, the Moon and Planets. There are 6 planets visible, one of which is visible at all times of the day. This is of course Earth, but during the night the other planets can be seen as the brightest 'stars' in the sky. The planet Uranus is just possible to see with the naked eye, but you have to be in a very dark location and have good sight so I have not counted it in the visible list.

There are a number of easily observed 'Deep Space Objects' that can be seen with the naked eye, but become progressively more interesting with different types of equipment. Among these the two most obvious are Pleiades (a stellar cluster) and the Great Nebula in Orion. To the naked eye these can easily be mistaken for clouds

or mist, but after a while you realize that they stay positioned relative to the surrounding stars. With a small telescope or binoculars they appear as faint grey smudges or pinpoint stars. A larger telescope realizes more detail and the Pleiades in particular appear as glowing lights in the sky.

Of course there are some things that are better seen without any equipment, and the foremost of these are meteor showers. Observing meteor showers requires you to have such a wide view of the skies that it makes using a telescope or binoculars pointless. All you need to do is wrap up warmly and lie back on a deckchair gazing at the stars.



deep space objects

Deep Space Objects are known as DSOs and refer to very faint features of the night sky. Generally these will be galaxies, clusters of stars or nebulae.

galaxy

A galaxy is a huge system of stars, planets, gasses and cosmic dust all bound together by gravity. Earth and the Solar System are part of our home galaxy, The Milky Way. The nearest galaxy to ours is the Andromeda Galaxy which is about 2,500,000 light years away.

stellar clusters

A cluster of stars or open cluster is a group of thousands of stars formed in the same region. These will all be of approximately the same age. A good example of an open cluster is Pleiades which can be seen unaided in the Taurus constellation.

nebulae

A nebula is an area of space filled with gas and cosmic particles. These are generally areas where stars are formed by the coming together of these particles over the years. Nebulas occupy huge areas of space often spanning many light years. The Great Nebula in Orion is a nebula visible without a telescope.

Moon rising over La Gomera/Photo: Roberto Porto

Why the moon is bigger closer to the horizon

By Kaelan Jungmeyer

We don't know. Not the writer, but the human population. That is not to say that there aren't many theories, but we don't know truly why.

First off, you should probably know that the moon does not get any bigger physically. In fact if you use your camera to take a picture of it when it is high in the sky, then again when it is at the horizon, then you will notice that it is the exact same size! If you look through your legs at the moon at the horizon, everything upside down will make the moon look the same size as when it was in the sky.

One theory is that when the moon is at the horizon, you have a point of reference. The buildings and trees make it seem bigger, while it seems small compared to the entire night sky. A similar thing happens in the ball illusion at the bottom. The center balls are the same size!

Another is that, since things at the horizon are generally farther away, the brain compensates and makes the moon seem larger, even though it is the same size.

MOON FACTS

The Earth's tides are largely caused by the gravitational pull of the Moon.

From Earth, we always see the same side of the Moon.

The Moon is the only extraterrestrial body that has been visited by humans.

The first space craft to send back pictures from the Moon was the Soviet Union's Luna 3 in October 1959.

The Moon is about 1/4 the size of the Earth.

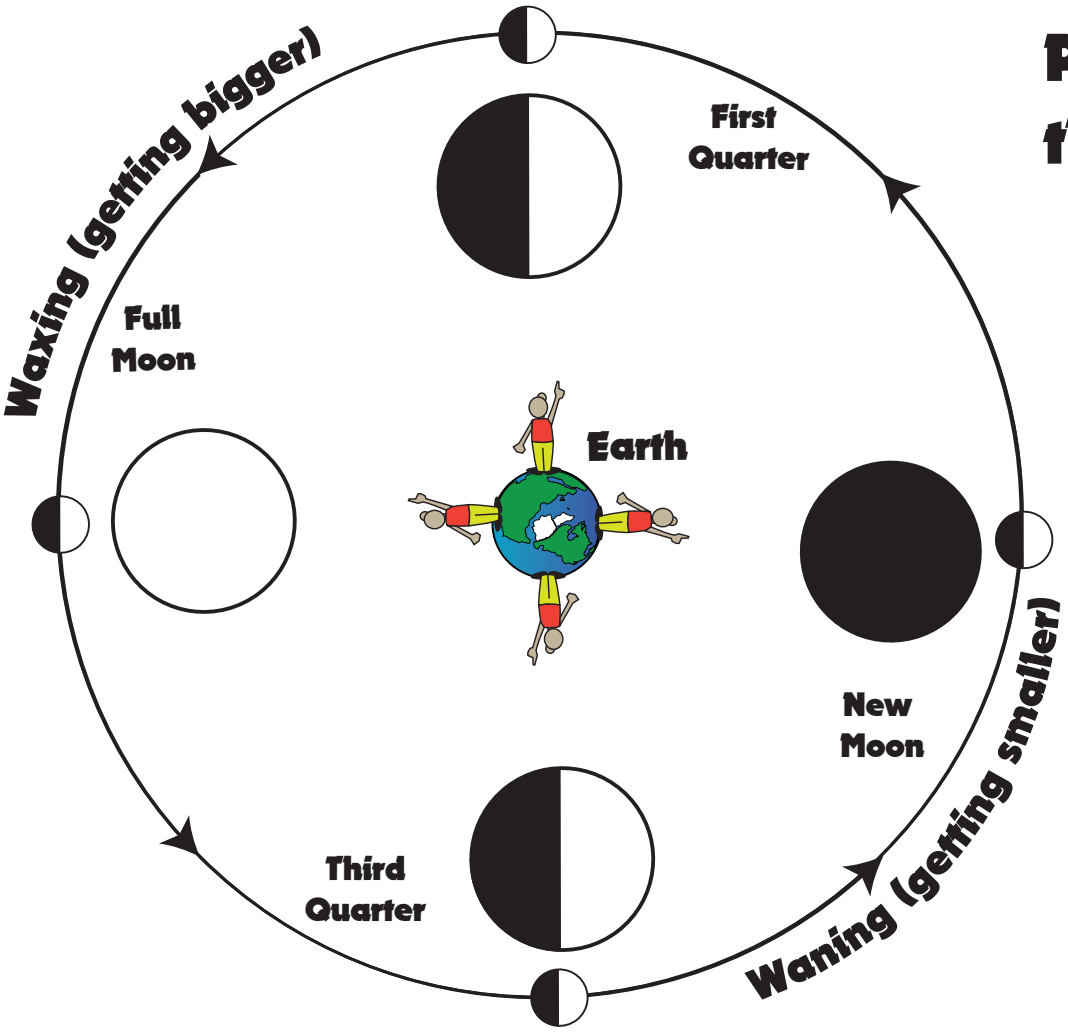
It is the fifth largest moon in the Solar System.

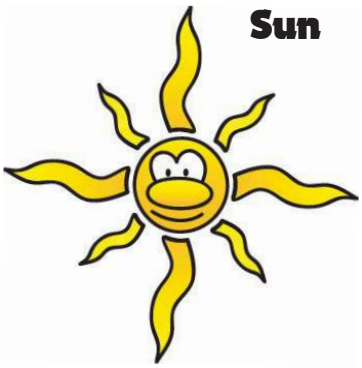
The average distance from the Moon to the Earth is 238,857 miles.

The Moon orbits the Earth every 27.3 days.

Mons Huygens is the tallest mountain on the Moon, it is 4,700 metres tall, just over half the height of Mt. Everest (8,848m).

Phases of the Moon





www.spaceplane.nasa.gov

www.science.nasa.gov/kids

Why does the Moon look different throughout the month?

The Moon has "phases." That means it looks a little different to us each night during its one-month orbit of our planet. We describe how the Moon looks with terms such as "Full Moon," "First Quarter," and "New Moon" (which we can't really see, because the side that is lit faces away from us).

The Moon has no light of its own. Moonlight is sunlight bouncing off the Moon's surface. As the Moon orbits Earth, the Sun lights up whatever side of the Moon is facing it. To the Sun, it's always a full Moon! If you were looking down upon Earth and its Moon from way out in space over the North Pole, you would see a Moon that looked like one of these:

But we see the Moon from the center of its orbit. So we see different portions of the lit side of the Moon.

Making Oreo Moon phases

This is a simple activity that most any kid, or adult, will enjoy. Open up a pack of Oreo cookies and scrape off (or knowing most people carefully bite off) the creme filling to make the four major phases of the Moon.

Each month, the portion of the Moon we see in the sky changes, passes through phases: growing from New Moon to Crescent to First Quarter to Gibbous to Full, then decreasing until it is back to New Moon once again.

These Oreo "Moons" show how the Moon looks from Earth during these phases as seen in the above illustration.

Curiosity busy on Mars

Story by Ken Kremer

As 2012 drew to a close, NASA's Curiosity Mars Science Lab (MSL) rover celebrated her first Christmas on the Martian surface and a resoundingly successful initial five months of exploration since the pulse pounding and unprecedented sky crane rocket powered touchdown on Aug. 6, 2012 inside Gale Crater beside a towering, layered mountain named Mount Sharp.

Meanwhile her older, smaller sibling Opportunity will soon celebrate an unfathomable nine Earth years on Mars on Jan. 24, 2013 - on the other side of the planet. At this very moment, Opportunity is investigating a spot inside Endeavour crater that is the most scientifically bountiful terrain yet of her entire incredible mission. It also promises to help unlock the mysteries of the Red Planets evolution from the warm, wet world of billions of years ago to the cold, arid landscape of today.

Curiosity has already made significant science discoveries in her short lifespan on the Red Planet and is in excellent health for the exciting journey's ahead in 2013. Locating the first drill target is the near term goal in January 2013. "That first drilling will be a huge moment in the history of Mars exploration," says John Grotzinger of Caltech, the project scientist for Curiosity.

At year's end, Curiosity was working at a spot called Yellowknife Bay. The SUV sized robot reached the shallow depression on Sol 130 (Dec. 17, 2012) after descending

Curiosity snaps a self portrait with Mount Sharp in the background at Rocknest ripple in Gale Crater on Sol 85 using the Mars Hand Lens Imager (MAHLI) camera on the robotic arm. This color mosaic was assembled from raw images taken Nov. 1, 2012. *Photo: NASA/JPL-Caltech/MSSS/Ken Kremer/Marco Di Lorenzo*

about two feet (0.5 meters) down a gentle slope inside a geologic feature dubbed Glenelg - selected by the MSL team as the rover's first major science destination for extended investigation.

She has already snapped over 35,000 images using the 17 on board cameras - including an amazing self portrait on Sols 84 & 85 at a windblown ripple dubbed Rocknest. See our panoramic mosaics herein from Yellowknife Bay, Rocknest and other stops along Curiosity's traverse route for a context view.

Just days before on Sol 120 (Dec 7, 2012) she stopped to inspect a huge outcrop of layered rocks dubbed Shaler and collected dozens of high resolution photos with the Navcam and Mastcam cameras. The Shaler outcrop features a plethora of striking layers, angled to each other in a pattern geologists refer to as 'crossbedding'.

After an 8.5 month interplanetary journey and safely surviving the harrowing touchdown at a site named 'Bradbury Landing', the robots science gear was powered up and checked out and the cameras collected an initial 360 degree panorama. Grotzinger calls this place "The Mojave Desert of Mars. The thing that's amazing about this is to a certain extent the first impression you get is how earth-like this seems, looking at that landscape."

The robotic arm was first flexed on Aug. 20 and dramatically pointed the way to Mount Sharp with the hand like tool turret - see our Sol 14 composite photo mosaic featured by NASA's Astronomy Picture of the Day (http://apod.nasa.gov/apod/ap120827.html) on 27 August 2012. Since then she's been on a roll to reach the inviting interior terrain of Glenelg before Christmas.

Glenelg is a geologist's paradise and uniquely sits at the junction of three different types of intersecting geologic features that will help unravel the secrets of the touchdown zone beside the humongous mountain Mount Sharp - the main destination of the mission.

Thus far the six wheeled robot Curiosity has traversed a total driving distance of some 0.43 mile (700 meters) and is now roving atop the most challenging and scientifically rewarding terrain of the entire five month journey. The science and engineering team guiding Curiosity is commanding her to accomplish ever more sophisticated and bold forays across the crater floor.

Along the short route travelled during the first 150 Sols, or Martian days, of the mission Curiosity already made the key science finding - namely the discovery of evidence for an ancient Martian stream bed at three different surface locations.

Curiosity found a trio of outcrops of stones cemented into layers of conglomerate rock - initially at the landing site and later while driving. The outcrops are named Goulburn, Link and Hottah. These findings show that hip deep liquid water once flowed vigorously on the floor of Gale Crater billions of years ago and validates the

Curiosity looks back to her rover tracks, the foothills of Mount Sharp and the eroded rim of Gale Crater in the distant horizon on Sol 24 (Aug. 30, 2012). The robot is taking the first radiation measurements from the surface to determine if future human explorers can live on Mars. Featured on PBS NOVA TV.

Photo: NASA/JPL-Caltech/Ken Kremer/Marco Di Lorenzo

choice of Gale Crater as the landing site. Liquid water is a prerequisite for the origin of life.

The $2.5 billion robot is the biggest and most sophisticated robot ever dispatched to the surface of another world and represents a quantum leap in capability. "Curiosity is NASA's first astrobiology mission to Mars since the Viking landers back in the 1970's," says Mike Meyer, Chief Mars scientist at NASA Headquarters in Washington, D.C.

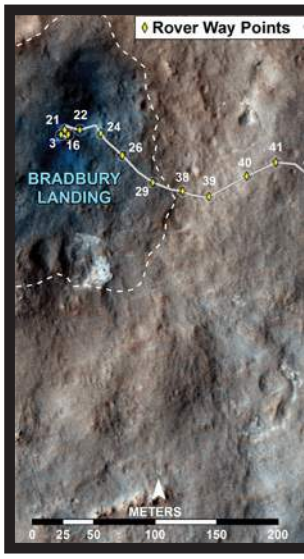
The 10 foot (3 meters) long mini Cooper sized Curiosity is loaded with 10 state-of-the-art science experiments weighing 15 times more than any prior roving vehicle. Some of the tools, such as the ChemCam laser-firing instrument for checking rocks' elemental composition from a distance of up to 25 feet, are the first of their kind on Mars.

The one ton mega rover is tasked with searching for the signatures of life, including organic molecules - the building blocks of life as we know it.

To enable the hunt for organics and determine the composition of Martian samples, Curiosity is equipped with a drill and scoop located at the end of its robotic arm, to gather soil and powdered samples of rock interiors. It will then sieve and parcel out these samples into the rover's high powered analytical laboratory instruments on the mobile rovers' deck.

During Autumn 2012, the rover made an intermediate stop of several weeks at the Rocknest ripple to check out and clean the sample handling mechanisms and then collect the initial scoops of sand to ingest into the chemistry labs.

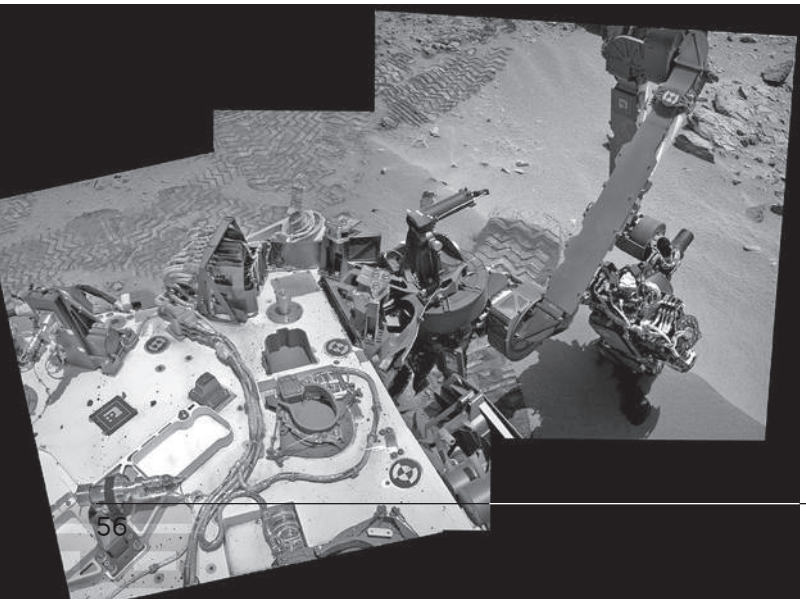
January marks the five month anniversary of her toiling on the spectacular Martian surface since the hair-raising pinpoint touchdown at the foothills of the gorgeous layered mountain holding deposits of hydrated minerals that may be the key to understanding Mars watery past and four billion plus years evolution.



The science team is now searching for an interesting rock for the inaugural use of the high powered hammering drill located on the turret at the terminus of the seven foot (2 meter) long robotic arm. The initial drilling had been planned for December but was delayed until after the holiday season due to concerns that frictional heating may potentially cause liquification of the rock to a gooey substance that could potentially clog the sample handling sieves and mechanisms. So the team is carefully re-evaluating which rock to target and the operating procedures for the percussive drill before committing to its initial usage.

The team chose to drive to Yellowknife Bay because it features a different type of geologic terrain compared to what Curiosity has driven on previously.

"The rover is traversing across terrain different from where it has driven earlier, and responding differently," said Rick Welch, mission manager at NASA's Jet Propulsion Laboratory, Pasadena, Calif. "We're making progress, though we're still in the learning phase with this rover, going a little slower on this terrain than we might wish we could."



Curiosity scoops up Martian soil sample on Sol 66 (Oct 12, 2012). Navcam image mosaic shows the robotic arm at work during scooping operations. Curiosity later delivered the first soil sample to the circular CheMin sample inlet at the center on the rover deck.

Photo: NASA/JPL-Caltech/Ken Kremer/Marco Di Lorenzo

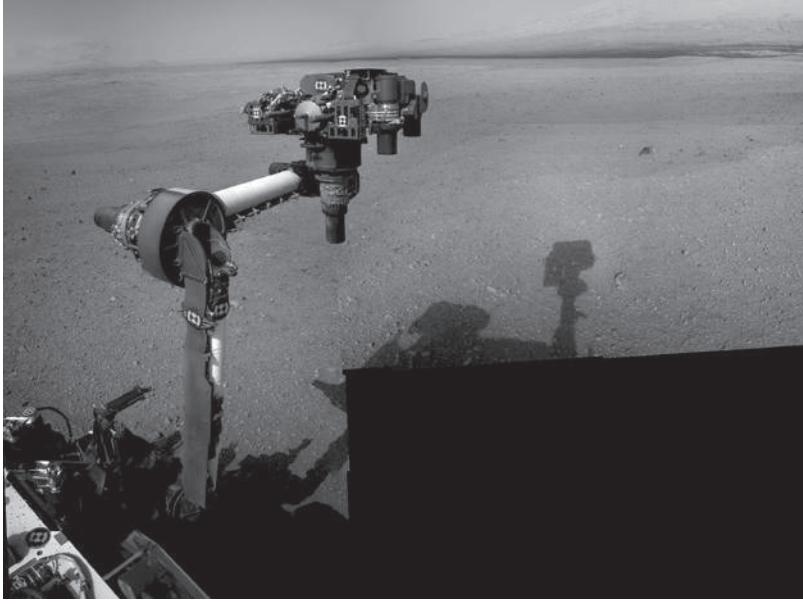
Curiosity arrived at the lip of Yellowknife Bay on Sol 124, entered the basin on Sol 125 (Dec. 12) and snapped a scouting panoramic view peering into the inviting locale. Another top priority was to acquire a high resolution 360 degree Mastcam color panorama. This will be invaluable for selection of the very 1st rock target to drill into and acquire a sample from the interior - a feat never before attempted on Mars.

The rover is also using the APXS X-ray mineral spectrometer, ChemCam rock blasting laser and MAHLI hand lens imager to gather initial science characterization data of Yellowknife Bay.

"We decided to drive to a place with a good view of the outcrops surrounding Yellowknife Bay to allow good imaging of these outcrops before the holiday break," says rover science team member Ken Herkenhoff. "As the images are returned during the break, we can use them to help decide where to perform the first drilling operation."

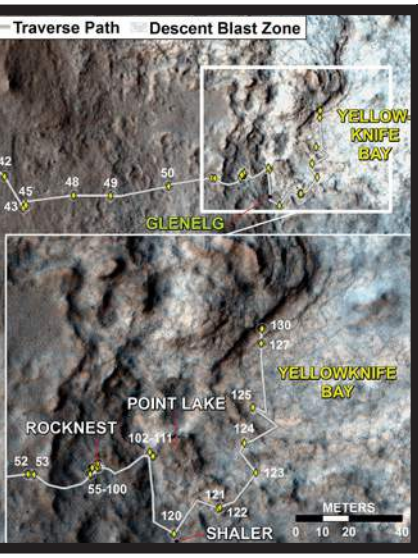
After a careful selection process, the team expects to choose the drill target sometime in January 2013 and use the robotic arm to deliver that initial, pulverized rock sample to inlet ports on the rover deck for analysis by the high powered duo of miniaturized chemistry instrument labs named Chemin (Chemistry and Mineralogy) & SAM (Sample Analysis at Mars).

CheMin and SAM will help elucidate the inorganic mineral composition as well as seek to determine if any organic molecules are present. SAM is specifically engineered to search for organic molecules using a Gas Chromatograph and Mass Spectrometer (GC-MS).



Curiosity Points the way to Mount Sharp. The rover deployed the robotic arm on Aug. 20 and aimed it directly at her ultimate Martian destination – the three mile high mountain named Mount Sharp.

Photo: NASA/JPL-Caltech/Ken Kremer/Marco Di Lorenzo



Sol 130 Curiosity Traverse Map. This map traces where Curiosity drove between landing at Bradbury Landing, and the position reached during Sol 130 (Dec. 17, 2012) at Yellowknife Bay which is inside an area called Glenelg. The inset shows the most recent legs of the traverse in greater detail.

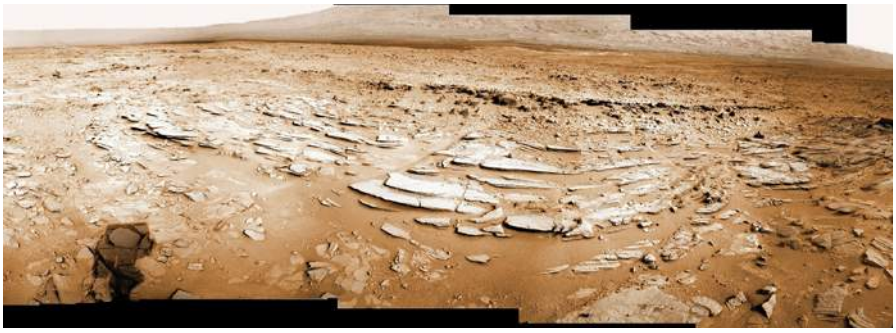
Graphic: NASA/JPL-Caltech/ Univ. of Arizona

CheMin uses X-ray diffraction techniques to accurately determine the mineralogical composition of pulverized and sieved red planet soil and rock samples.

Curiosity will spend at least another month or more investigating Glenelg before setting off on the nearly year long trek to her main destination - the sedimentary layers of the lower reaches of the three mile (5 km) high mountain named Mount Sharp. Along the way, the science team may possibly choose to re-investigate the Shaler and Hottah outcrops with the rover's suite of science instruments.

As the Martian crow flies, the environs of Mount Sharp are some six miles (10 km) away. Curiosity will have to carefully navigate across a treacherous dune field to get there. The team projects it will take about a year or so before Curiosity arrives at the base of Mount Sharp and begins the ascent in between the breathtaking mesas and buttes lining the path upwards to the sedimentary materials.

Climbing Mount Sharp and exploring the embedded water related phyllosilicate clays and sulfate minerals are the ultimate goals of Curiosity's mission. Scientists are searching for evidence of habitable zones that could have supported Martian microbial life -past or present - during the two year primary mission phase. Gale Crater is unlike anything we've seen before on Mars.



Sol 120 colorized panorama shows big Shaler layered rock outcrop snapped by Curiosity's right eye Navigation Camera (Navcam) on Dec. 7, 2012. Shaler exhibits a pattern known as 'crossbedding', at angles to one another. Mount Sharp visible in the background.

Photo: NASA/JPL-Caltech/Ken Kremer/Marco Di Lorenzo

"NASA Socials let space enthusiasts meet and spread information to those who can't be there in person. We all nerd out on how cool humans can be."

– Seth Green

Pictured in descending order from the top left: BoingBoning's Xeni Jardin and actor Seth Green; Following the Mars Curiosity rover's landing, NASA's Courtney O'Connor goes in for a high five; MSL Curiosity NASA Social group photo with NASA Administrator Charles Bolden; The engineering prototype rover Scarecrow in JPL's Mars Yard.

Getting Social with NASA

By Brandon Fibbs and Nicole Solomon

The city of Los Angeles is no stranger to celebrity sightings. But for a few days last summer, well-heeled movie stars traded places with some of NASA's best and brightest scientists and engineers.

In what was described by John Holdren, President Obama's senior science advisor, as "the most challenging mission ever attempted in the history of robotic planetary exploration," NASA's Jet Propulsion Laboratory (JPL) landed an SUV-sized rover named Curiosity on the surface of Mars, following a diabolically complex and breathtaking feat of engineering. After nearly 10 years and $ 2.5 billion worth of effort, the rover, humanity's best hope so far for finding microbial alien life on the Red Planet, dazzled the world with a picture-perfect landing.

Curiosity is the latest in a series of progressively advanced rovers to visit the fourth planet from our sun. Before Curiosity, the popular twin rovers Spirit and Opportunity left their marks in the scarlet soil. Designed to operate for only 90 days, the rovers wildly exceeded everyone's expectations. Opportunity, still exploring, has been roving for nearly nine years.

JPL hit upon a simple yet clever way to make people care about the science coming out of the prestigious Pasadena campus: they gave the robotic emissaries their own online voice, imbuing them with a personification usually reserved for the likes of Disney cartoon animals. It worked. The public was hooked. When Curiosity joined its hearty brethren, it too was already well on its way to becoming a national social media obsession. Moments after touchdown, Curiosity, via its Twitter account (@MarsCuriosity), announced, "I'm safely on the surface of Mars. GALE CRATER I AM IN YOU!!!"

NASA recently announced plans for the launch of another robotic science rover in 2020.

Curiosity's first-person voice is supplied by a small but enthusiastic team of NASA/JPL communication professionals led by Veronica McGregor (@VeronicaMcG) who, back in 2008, already was channeling the Mars Phoenix lander. With nearly 1.2 million Curiosity followers (and more than 465,000 Facebook fans), it is obvious that McGregor and her social media team: Stephanie Smith (@Stephist) and Courtney O'Connor (@CourtOConnor) are on to something big. But they didn't stop there. Dedicated to getting the word out to as many people as possible, McGregor

held NASA's first ever Social in 2009, an event that allowed guests a once-in-a-lifetime experience, exclusive access to scientists, engineers and astronauts, as well as the NASA facilities at which they work.

"Our first social was a three-hour event," McGregor said. "I wanted the time to be convenient for people driving in from all parts of Los Angeles. What I didn't expect was that we would get people flying in from all across the country! That was the first hint that these socials were going to be a hit. There were several people who questioned the value of holding that first event. I think I saw a few snickers behind my back. But within six months, socials were being held at NASA Headquarters and other NASA field centers. By the end of the year, they were being held at Kennedy Space Center for space shuttle launches. Safe to say no one questions the value of socials anymore!"

NASA's budget may be a paltry half a penny on the tax dollar, but you'd never know it based on their vibrant online presence. Arguably the most loved and lauded government agency, NASA enjoys a social media footprint second only to the White House, and has won numerous government and internet awards for its efforts to engage the public.

MSL Curiosity NASA Social attendees Abraham Benrubi and Susan Bell.
Photo: Nicole Solomon

Members of NASA's social media team. From left to right. JPL's Veronica McGregor. JPL's Stephanie Smith. NASA HQ's John Yembrick. NASA HQ's Jason Townsend. JPL's Courtney O'Connor.
Photo: Nicole Solomon

"Our attendees are citizen journalists who communicate to their audiences with their tweets, posts, photos and videos," McGregor said. "Millions of potential impressions are generated with each event."

One of those attendees was John Zeller (@JohnLukeZeller), founder of the website #Penny4NASA. Zeller was one of 2,300 people who applied for the Mars Curiosity social. Only 26 got in.

"These socials are so important because they're getting the word out to people who aren't already tuned in," Zeller said. "The most important thing is getting people educated — this stuff sells itself once they are exposed to it."

Susan Bell (@susanbellfilm), a film and television producer who dreamed of becoming an astronaut as a child was inspired to get her pilot's license after a visit to a NASA field center. "NASA isn't in the news enough. People need to know what's going on. In this day and age, with all the funding issues, the more people who know the amazing things NASA is doing, the better. We need to spread the word about how much value there is in what NASA does." Susan said.

While at JPL, NASA Social participants were treated to a slew of high-ranking NASA officials, including NASA Administer Charles Bolden, Deputy Administrator Lori Garver (@Lori_Garver), JPL Director Charles Elachi, astronaut John Grunsfeld (@SciAstro), and a handful of senior engineers responsible for getting Curiosity safely to its new home, including Mars Science Laboratory Mechanical Systems Lead Adam Steltzner (@Steltzner). They also attended NASA briefings and asked questions, alongside members of the national and international press.

> "It was the most exciting, heart-wrenching, deliriously joyful event I have ever experienced."
>
> – *Abraham Benrubi*

"I never dreamed I'd be at the sort of NASA press conferences I've watched on TV all my life," said Brad Snowder (@skywise88), an astronomy professor and amateur telescope maker. "Talk about geek juice — it's like I've been mainlining this week. It's geek heaven."

That's exactly the sort of reaction NASA is hoping for.

"So much of what we do in communications is a one-way

transmission of message," said Michael Cabbage, director of news and multimedia at NASA Headquarters in Washington, DC." But with social media it's two-way — transmitting and receiving. There's a dialogue. That's the way of the future."

NASA Social Media Manager John Yembrick (@Yembrick), agrees. "NASA has a unique story that resonates with a lot of people from around the world. Whether we participate or not, folks on social media are going to discuss NASA, our missions, and our brand. Social media allows us to be part of that conversation. Through our social media efforts, we're seeing a whole new level of interest in science, technology, engineering and math, which we hope will inspire the next generation of explorers."

The three-day event wasn't all lectures and press conferences. The attendees also took in a theatrical presentation of the popular viral hit, "Seven Minutes of Terror". They also were given a demonstration of "Eyes on the Solar System." A 3-D environment populated with real NASA mission data by popular creator Doug Ellison (@Doug_Ellison), and toured JPL's Mission Control and the popular Mars Yard, where test rovers traverse simulated Martian rock fields. Before NASA Socials, this sort of access was reserved for VIPs and visiting dignitaries.

"Seeing the looks on the faces of people as they did the tour made my day," McGregor said. "The attendees seemed flattered that mission personnel would talk to them and take their questions, but on the other hand our teams love to tell their story."

While NASA Socials are populated by citizens from all walks of life, they frequently draw more recognized faces as well. Actor Seth Green (@SethGreen), who attended a NASA Social for the final launch of the space shuttle, considers himself a lifelong fan of the agency.

"The Internet has made it possible for people all over the world to share these world-changing events," Green said. "NASA Socials let space enthusiasts meet and spread information to those who can't be there in person. We all nerd out on how cool humans can be."

Green isn't the only movie star smitten by NASA's work in the final frontier. NASA Social attendees also were able to rub elbows with surprise celebrity guests like Star Trek's Nichelle Nichols and Wil Wheaton (@wilw), The Big Bang Theory creator, Bill Prady (@BillPrady), Black Eyed Peas' frontman will.i.am (@iamwill), and Jeopardy's Alex Trebek.

NASA Socials draw like-minded participants from all corners of the globe, creating deep and lasting bonds among participants, who frequently end up rooming together and spending every free minute in each other's company. They commonly create online communities to stay in touch and launch their own reunion events to relive the moments they shared, and strategize how better to advocate for their mutual passion.

"Once space fans find each other, they tend to stick together," an understandably satisfied McGregor said.

In the minutes leading up to Curiosity's landing, the tension in the auditorium housing the social attendees and expectant members of the press could be carved with a knife. With each success of Curiosity's chain of impossibly difficult descent procedures, the social attendees erupted in euphoric applause. When the call went out that Curiosity was safely on the surface, that euphoria manifested itself as an exuberant demonstration of affection and tears of elation.

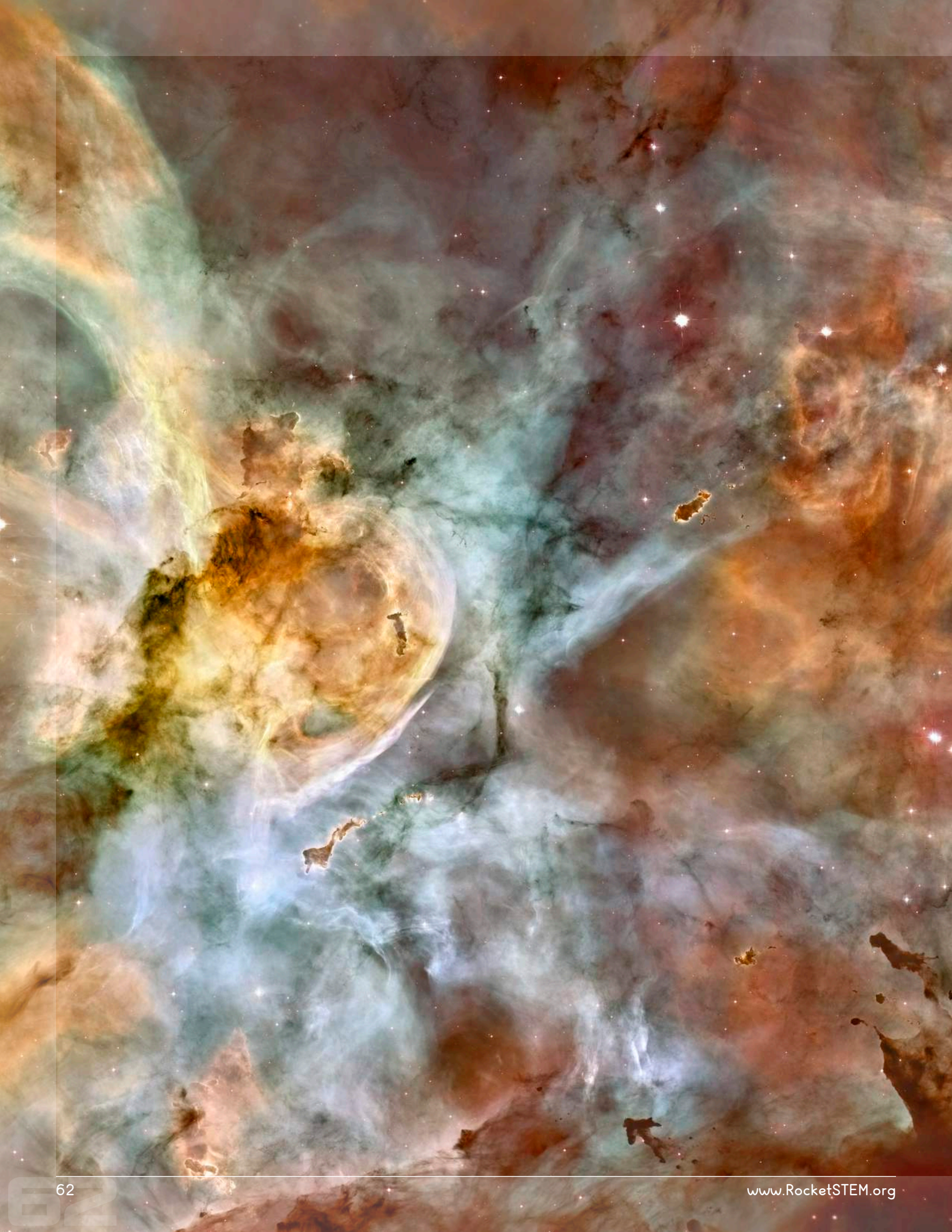
"It was the most exciting, heart-wrenching, deliriously joyful event I have ever experienced," said actor Abraham Benrubi (@AbrahamBenrubi)." It was an historic achievement for mankind. To have been able to soak up that level of joy is a once in a lifetime moment."

NASA knows Benrubi's feelings mirror that of his fellow participants. And the agency knows with each social it holds, NASA gains supporters exponentially. Unlike any other facet of the government, NASA's mission inspires the hopes and dreams of a country beset by financial doldrums and social turmoil. NASA's explorers, whether human or robotic, represent the very best of American ideals and potential.

MSL Curiosity NASA Social attendees hard at work. *Photo: Nicole Solomon*

While NASA has announced only two socials for 2013 thus far — the launch of the TDRS-K satellite from Cape Kennedy in Florida, and the launch of the Landsat Data Continuity Mission (LDCM) from Vandenberg AFB in California — more are in the works, including socials with astronauts, scientists, engineers, and, of course, other launches, including one at a NASA center which has never hosted such an event before.

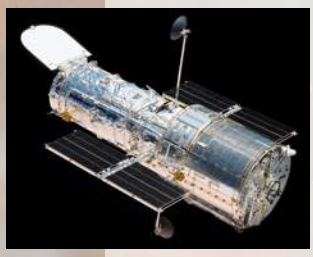
"NASA Socials create lifelong ambassadors of the space program," Yembrick said. "It's the gift that keeps on giving."



Hubble views our Milky Way

Carina Nebula, NGC 3372

Shown on these two pages is a 50-light-year-wide view of the central region of the Carina Nebula where a maelstrom of star birth — and death — is taking place within the Milky Way Galaxy.



This image is a composite of many separate exposures made by the ACS instrument on the Hubble Space Telescope along with ground-based observations. In total, three filters were used to sample narrow wavelength emission. The color results from assigning different hues (colors) to each monochromatic image. The Hubble images were taken in the light of neutral hydrogen while color information was added with data taken at the Cerro Tololo Inter-American Observatory in Chile. Red corresponds to sulfur, green to hydrogen, and blue to oxygen emission.

Image: NASA/ESA/N. Smith (University of California, Berkeley)/Hubble Heritage Team (STScI/AURA)

Host a conversation with crewmembers aboard the ISS

NASA is now accepting proposals from U.S. schools, museums, science centers and community youth organizations to host an Amateur Radio on the International Space Station, or ARISS, contact between May 1 and Nov 1, 2013. To maximize these radio contact opportunities, NASA is looking for organizations that will draw large numbers of participants and integrate the contact into a well-developed education plan. Proposals are due Jan. 28, 2013.

Using amateur radio, students can ask astronauts questions about life in space and other space-related topics. Students fully engage in the ARISS contact by helping set up an amateur radio ground station at the school and then using that station to talk directly with a crew member on the International Space Station for approximately 10 minutes. The technology is easier to acquire than ever before. ARISS has a network of mentors to help organizations obtain the technology required to host this once in a lifetime opportunity for students.

Interested parties should visit www.nasa.gov/education/tfs/ariss to obtain complete information, including how the technology works, what is expected of the host and how to submit the proposal.

Questions should be emailed to JSC-TFS-ARISS@mail.nasa.gov.

REEL Video Contest

So you want to be a NASA producer? NASA is looking for talented high school students to create videos that engage students in earth science.

NASA earth science missions are kicking off a new video contest challenging high school students to produce a two-minute video for middle school students. The videos should focus on one of three topics: Ozone in the Stratosphere, Ship Tracks and Our Environment, or The Water of the Water Planet.

Winning videos will be posted on NASA's website. Winners will also get the opportunity to be a NASA producer working with NASA scientists and communication experts in July 2013 to produce an earth science feature video.

The deadline for submitting videos is Feb. 15, 2013.

For more information and instructions, visit http://aura.gsfc.nasa.gov/reelscience.

Questions about the video contest should be emailed to Ginger Butcher at ginger.butcher-1@nasa.gov.

Entries sought for research contest

The Institute for Global Environmental Strategies is currently accepting entries for the 2013 Thacher Environmental Research Contest. The contest is open to U.S. students in grades 9-12. Entries should demonstrate the best use of geospatial tools or data to study our home planet. Eligible geospatial tools and data include satellite remote sensing, aerial photography, geographic information systems and the Global Positioning System. The main focus of the project must be on the application of the geospatial tool(s) or data to study a problem related to Earth's environment.

Applicants must be U.S. citizens. Students in public, private, parochial, Native American reservation and home schools are eligible. Entries may be submitted by individuals or teams. Cash awards will be given to students in the top three places. Awards will also be given to the winning students' teachers.

Entries must be postmarked by April 15, 2013. Entries may also be submitted electronically.

For more information, visit http://bit.ly/thacher.

Questions should be emailed to ThacherScholars@strategies.org.

Registration open for the NASA Great Moonbuggy Race

Registration is open for the 20th Annual NASA Great Moonbuggy Race. High school and college students are challenged to design and build a vehicle that addresses a series of engineering problems similar to those faced by the original lunar-roving vehicle team. Each school may enter up to two teams. The race will take place April 25-27, 2013, in Huntsville, Ala., at the U.S. Space & Rocket Center.

U.S. teams must register by Feb. 4, 2013.

For more information about the competition and to register online, visit http://moonbuggy.msfc.nasa.gov/index.html.

Teams with questions should contact Diedra Williams at Diedra.A.Williams@nasa.gov.

e-PDN course open

NASA's Learning Environments and Research Network and the Georgia Institute of Technology have teamed up to create the Electronic Professional Development Network, or e-PDN, an initiative dedicated to preparing K-12 teachers to engage their students in science, technology, engineering and mathematics, or STEM, through the use of NASA-developed learning materials and resources.

If you are looking for a way to enhance your instructional skills, meet your professional development goals or find new and exciting resources to use in your learning environments, apply to one of our free courses today!

Applications are now open for the following course: Project-Based Inquiry Learning: Science Teaching and Learning for the 21st Century -- March 13 - April 16, 2013

Develop your skills in designing and using project-based inquiry learning, or PBIL, to enhance conceptual understanding, critical

thinking, scientific reasoning and problem solving in standards-based classrooms. Experience and analyze two NASA-oriented PBIL projects firsthand; learn PBIL curriculum design strategies and methods; and design a PBIL unit for use in your classroom. Use e-PDN's suite of online tools to collaborate, connect and create with other course participants.

To learn more about this free course and to apply online, visit http://bit.ly/reelcontent.

For more information on the ePDN and the resources it offers to K-12 teachers, visit www.nasaepdn.gatech.edu.

Questions should be directed to Kristen Anderson at kristen.anderson@pe.gatech.edu.

Space Exploration Educators Conference set

Make plans to attend the 19th Annual Space Exploration Educators Conference, to be held Feb. 7-9, 2013, at Space Center Houston. This conference is for all K-12 educators. Activities presented use space-related themes to teach across the curriculum and can be used for science, language arts, mathematics, history and more.

Attend sessions hosted by scientists and engineers working on the International Space Station, Mars exploration and the planets beyond. Hear from astronauts who will be leading the charge in exploration. Attend sessions presented by educators and receive ready to implement classroom ideas. Attendees can earn up to 24 hours of continuing professional education credit.

Keynote speakers scheduled to attend include astronaut Satoshi Furukawa and actor LeVar Burton.

For more information, visit http://bit.ly/speeconf.

If you have any questions, please call 281-244-2149 or email seec@spacecenter.org.

What's new at NASA's Space Place website

Earth is in the lucky position to have a love-hate relationship with its star. We say lucky, because obviously we couldn't live without it, but at times it's a little difficult to live with it as well. We call the conditions around our planet, outside of its own atmosphere and magnetosphere, space weather, but it affects us on Earth, too.

Let's Start Here

"Space Place Live!" is a cartoon talk show where Space Place characters interview real NASA scientists and engineers. The latest episode stars Merav Opher, astrophysicist. She studies how stars work. In this seven-minute video, we learn about the solar wind, solar flares, the heliosphere and the environment the sun creates. Dr. Opher also talks about how she got interested in physics and what she likes to do for fun. Check it out at http://spaceplace.nasa.gov/space-place-live/#opher.

Spotlight on All Things Sunny…

Heliophysics, or the physics of the sun, is one of the four major science thrusts of NASA's Science Mission Directorate. (The others are astrophysics, Earth science and the solar system.)

The sun-Earth connection is so important in understanding our immediate environment. The Sun menu (http://spaceplace.nasa.gov/menu/sun) offers activities, games and fun facts about the sun and how it affects Earth. The most comprehensive treatment of this relationship is the animated, narrated storybook "Super Star Meets the Plucky Planet: Or, how Earth and Sun come to mutual understanding and respect." It is also available to print and read aloud (http://spaceplace.nasa.gov/story-superstar).

For the Classroom

The Gallery of Sun images (http://spaceplace.nasa.gov/gallery-sun) is just for teachers to print and post in the classroom. They have large, simple captions.

For Out of School Time

"Satellite Insight" is an absorbing game for all ages that runs on both computer and iPhone or iPad. It is Tetris-like, where six tile colors represent different types of data measured and recorded by the Geostationary Operational Environmental Satellite – R Series, or GOES-R, satellite. Bonus material explains what each of the tile colors stand for, such as clouds, lightning and solar energy. A lot of them stand for data related to space weather. See http://spaceplace.nasa.gov/satellite-insight.

Special Days

Jan. 31, 1958: Explorer 1 was the first U.S. satellite launched into orbit.

How do orbits work, anyway? Find out by putting a cannonball into orbit! http://spaceplace.nasa.gov/how-orbits-work

Feb. 19, 1473: Nicolaus Copernicus born.

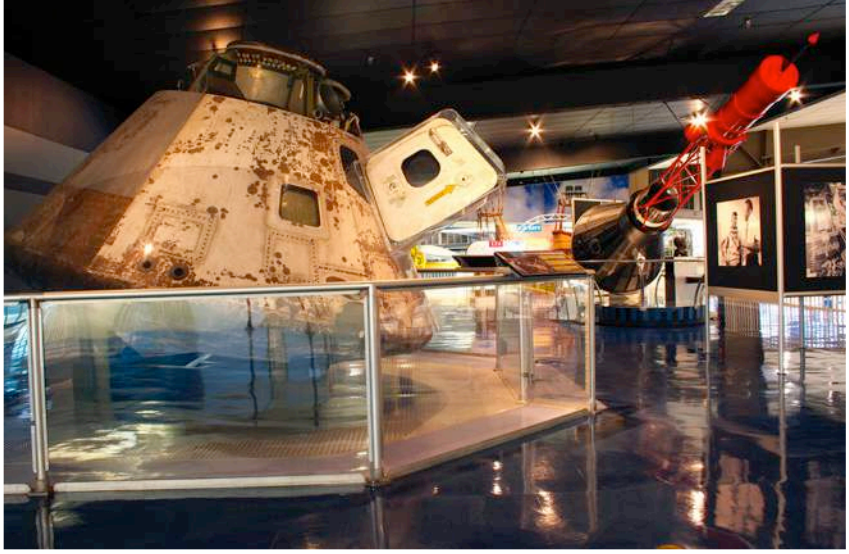
He thought the sun was the center of the universe. He was wrong. But just where is the center? Dr. Marc answers in a short podcast. http://spaceplace.nasa.gov/podcasts/#center

Feb. 22: Thinking Day

The "Spitzer" memory game will make you think very hard. http://spaceplace.nasa.gov/spitzer-concentration

Don't Forget…

You can find dozens of other ideas and rich resources for the classroom and out-of-school time at our Parents & Educators page, http://spaceplace.nasa.gov/menu/parents-and-educators.



The sky is not the limit at the

Nestled along the coastline of the Florida Panhandle, nearly equal distance from historic Kennedy and Johnson Space Centers, is a place most well known for its sugar white sand beaches. But Pensacola, Fla. has its own page in the annals of space exploration, as many of the astronauts from the Golden Age of space exploration first took to the skies above Naval Air Station Pensacola.

Naval aviation has also been at the cutting edge of aerospace expeditions, from the first successful crossing of the Atlantic by an aircraft to the exploration of the Arctic and Antarctic. The common denominator for those who participated in this exciting history was their training at Pensacola where they learned the unique skills required to fly from ships at sea, find distant targets and return to their moving, rolling and pitching "airfield," often in bad weather and frequently at night.

The National Naval Aviation Museum, located aboard NAS Pensacola, deftly conveys that history to visitors as it transcends both time and space, from wood and fabric biplanes to modern jet aircraft and even the frontiers of outer space. The museum, which is open to the public, captures naval aviation's heritage and brings its story alive.

With nearly 300,000 square feet of exhibit space, the museum is the world's largest museum devoted to naval aviation. More than 150 beautifully restored aircraft representing the Navy, Marine Corps, and Coast Guard are on display.

Among the space artifacts to be seen at the museum are the Apollo command module that carried an all-Navy crew to Skylab, America's first space station, and a Moon rock from the Apollo 17 mission, as well as a variety of other items. There is a new full-size replica of the Lunar Excursion Module located in Hangar Bay One. The Navy has been so well represented in the astronaut corps that both Skylab and the International Space Station have had a ship bell placed within them.

"The first American in space was a naval aviator," said Gene Cernan who flew to space three times (Gemini IX, Apollo 10, Apollo 17). "The first American to orbit the Earth was a naval aviator, a Marine but wore Navy wings of gold. The first American on the Moon was a naval aviator. The last American to leave

Photos: Chase Clark

National Naval Aviation Museum

his footsteps on the surface of the Moon was a naval aviator. Five out of six lunar landings were commanded by naval aviators.

"It's not that naval aviators are any better than Air Force aviators. But I think the differentiating factor is that in naval aviation we do two things. We give a lot of decision making to the naval aviator, as to his fate, as to accomplishing his mission," continued Cernan. "When the time comes to make a decision that you have to make, you'd better make it.

"The other thing I really think is that the next step beyond just flying supersonic, or landing, or flying high-performance aircraft and whatever, is the requirement to take that machine which you are flying in the middle of an ocean, at night, and land aboard an aircraft carrier. I'm telling you that I believe every Air Force pilot that was in the space program could have done it having been given the chance, but he didn't. And he didn't have that kind of requirement placed upon him throughout his career. Where Navy guys, you had to perform, or you busted your butt. It was that simple. Because when you are coming aboard a carrier at night, it is only you and your maker. And it's like that landing on the Moon. Either you are going to do it, or you're not going to do it," said Cernan.

The National Naval Aviation Museum began with the vision of one man who got his first taste of flying in Pensacola. In 1955, Magruder H. Tuttle, a Navy captain, was concerned that the training curriculum offered the students no exposure to the history of naval aviation. A small museum was proposed and by June 1963, it had opened its doors. It was a modest start as with a mere 8,500 square feet, only eight aircraft were able to be displayed.

The expanding collection of aircraft quickly overwhelmed the capacity of the museum which has undergone several expansions. During the past 50 years, the museum has acquired more than 700 aircraft.

Among those on display are record-setting aircraft like the NC-4 flying boat, the first plane to fly across the Atlantic, as well as combat veterans, including the SBD Dauntless that flew at the Battle of Midway, two Vietnam MiG-killers, an A-7 Corsair II that logged missions over Iraq during Operation Desert Storm and

the last F-14 Tomcat to fly a combat mission.

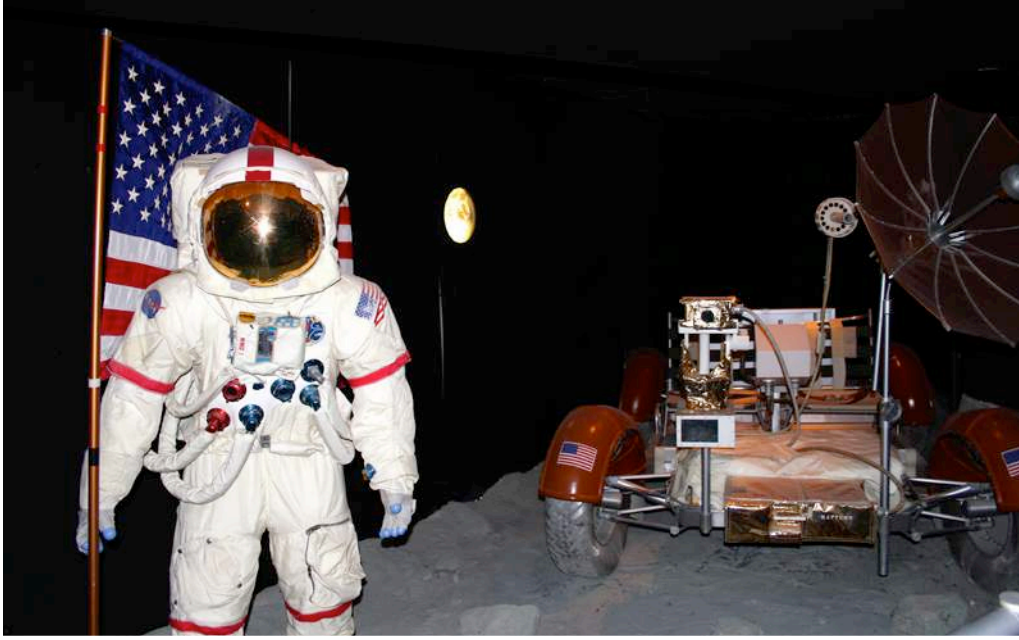
Between March and November each year, the Navy's legendary Blue Angels flight demonstration squadron can be seen practicing precision maneuvers in the skies above the museum.

Visitors are welcome to climb inside one of the 35 actual cockpit trainers, flip the switches, turn the knobs and let their imaginations soar. There also is a motion-based simulator ride which allows visitors to experience horizontal rolls, longitudinal pitches and vertical climbs. The museum also contains an IMAX theater with daily showings of 'The Magic of Flight' which takes viewers airborne with the Blue Angels.

More than 4,000 uniforms, flight gear, weaponry, medals and decorations add a personal touch to the museum. 'Home Front USA,' 'Pacific Air Base' and 'The Hangar Bay,' provide visitors an opportunity to walk through a small-town Main Street (circa 1943), a U.S. Marine Corps expeditionary airfield during the Guadalcanal campaign and the hangar bay and below-deck spaces of a World War II aircraft carrier.

Many of the museum's volunteers are retired or active duty personnel who bring life to the displays as they give guided tours and recite their very own sea tales.

What began as one man's vision to endow young aviators with an appreciation of their heritage, has evolved over the years into a steadily growing and expanding institution of national significance.



Photos: Chase Clark

We hope you enjoyed this first issue of RocketSTEM magazine. We also hope you learned a few things while reading it. We intend to release new issues of the publication in April and June of this year, before moving to a monthly publication schedule beginning in August. We welcome your comments and suggestions for how to improve the magazine, and are always open to additional contributors. Please feel free to email us at **ideas@rocketstem.org** with your feedback or story ideas.

RocketSTEM is a non-profit media foundation centered around promoting STEM education and space exploration. Our mission is to a) inspire the next generation of scientists, engineers and astronauts; b) keep educators informed on space developments while helping them better incorporate STEM lessons into their classrooms; and c) raise awareness of the benefits of space exploration.

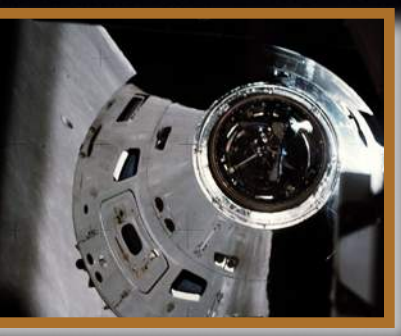
This digital publication is available for free. It may be viewed online at **www.rocketstem.org**, or downloaded as a PDF file.

"Mystery creates wonder
and wonder is the basis
of man's desire
to understand"

– Neil Armstrong
Apollo 11 Commander
First Man on the Moon

#winkatthemoon

Photos: NASA




"I'm on the surface; and, as I take man's last step from the surface, back home for some time to come — but we believe not too long into the future — I'd like to just [say] what I believe history will record. That America's challenge of today has forged man's destiny of tomorrow. And, as we leave the Moon at Taurus-Littrow, we leave as we came and, God willing, as we shall return: with peace and hope for all mankind. Godspeed the crew of Apollo 17."

– Gene Cernan, Apollo 17 Commander




Photos: NASA