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National Aeronautics and
Space Administration

KENNEDY SPACE CENTER'S

SPACEPORT magazine

THE [REAL] MARTIANS

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

KENNEDY SPACE CENTER'S

SPACEPORT MAGAZINE

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Front Cover: Kennedy Space Center employees are enabling the Journey to Mars. Image credit: Glenn Benson

Back Cover: NASA's Solar Dynamics Observatory captured this image of a solar flare – as seen in the bright flash in the lower right hand side of the sun – on Sept. 28, 2015. The image shows a subset of extreme ultraviolet light that highlights the extraordinarily hot material in flares and which is typically colorized in red. Credit: NASA/SDO

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KSC BLOG

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NASA'S LAUNCH SCHEDULE

Date: Oct. 1, 12:49 p.m. EDT
Mission: Progress 61P Cargo Craft
Description: The Progress resupply vehicle is an automated, unpiloted version of the Soyuz spacecraft that is used to bring supplies and fuel to the International Space Station, or ISS. The Progress also has the ability to raise the station's altitude and control the orientation of the station using the vehicle's thrusters. It normally docks to the end of the station's Zvezda Service Module, but it also can dock to the bottom of the Pirs Docking Compartment.

Date: Nov. 21
Mission: Progress 62P Cargo Craft
Description: The Progress resupply vehicle is an automated, unpiloted version of the Soyuz spacecraft that is used to bring supplies and fuel to the ISS.

Date: Dec. 15
Mission: Expedition 46 Launch to the International Space Station
Description: NASA astronaut Tim Kopra, ESA astronaut Tim Peake, and Yuri Malenchenko of Roscosmos will launch to the ISS aboard a Soyuz spacecraft from the Baikonur Cosmodrome, Kazakhstan.

Date: March 2016
Mission: InSight (Interior Exploration Using Seismic Investigations, Geodesy and Heat Transport)
Description: Mission will study the deep interior of Mars to advance understanding of the early history of all rocky planets, including Earth.

I am KENNEDY SPACE CENTER

CALEY BURKE

I am an aerospace engineer performing flight design mission analysis for NASA's Launch Services Program, or LSP. My job involves ensuring the rocket's trajectory safely delivers NASA's robotic spacecraft to the right place at the right time with contingency fuel. In flight design, we often start working with spacecraft in early development stages, guiding them in the capabilities of the U.S. launch vehicle fleet and vehicle selection.

I enjoy working with the spacecraft and launch vehicle analysts; we get to know the spacecraft, its unique needs, and how the rocket can meet them all. Up next for me is InSight, a lander investigating Marsquakes and geology, which is the first West Coast interplanetary launch. I've also held the NASA winds and flight dynamics engineer roles on console for launch.

In my outreach/innovation time, I venture outside of analysis. I'm active in public social media, both personally @NASA_Caley and for several organizations. For launches I'm not working, I post with LSP's team from the launch console engineers' perspective. I update supporters of LSP's FIRST Robotics Team 1592 on the Bionic Tigers' activities.

Through Spaceport Innovators, I lead Kennedy experts in creating challenges for the International Space Apps Challenge, NASA's global hackathon and an innovation incubation program. We educate and connect with the thousands of participants around the world and in Central Florida, crowdsourcing to solve challenges relating to Kennedy's current work. The participants are enthusiastic to learn and work with us; it's so rewarding to see the ideas and prototypes developed.

STARLINER

Boeing revamps production facility for Starliner flights

BY STEVEN SICELOFF

Meet the CST-100 Starliner, the newly unveiled name of Boeing's commercial crew transportation spacecraft. It's been designed with a focus on automated flight, reliable operation and frequent flights carrying NASA astronauts to the space station. It also may take paying customers to the awe-inspiring heights of low-Earth orbit and the unique sensation of sustained weightlessness.

NASA last year awarded contracts to Boeing and SpaceX to each develop systems that will safely and cost effectively transport astronauts to the International Space Station from the United States.

The CST-100 will be assembled and processed for launch at the revitalized Commercial Crew and Cargo Processing Facility, or C3PF, at Kennedy Space Center. NASA had used the facility for 20 years as a shuttle processing hangar and for the extensive preps and testing of the space shuttle main engines in the engine shop.

"One hundred years ago we were on the dawn of the commercial aviation era and today, with the help of NASA, we're on the dawn of a new commercial space era," said Boeing's John Elbon, vice president and general manager of Space Exploration. "It's been such a pleasure to work hand-in-hand with NASA on this commercial crew development, and when we look back 100 years from this point, I'm really excited about what we will have discovered."

With the high bay of the C3PF expected to be complete in December 2015, engineers are building the structural test article for the Starliner in the remodeled engine shop. Though not scheduled to ever make it into space, the test version of the spacecraft will be put through a continuum of tests culminating with a pad abort test in 2017. It will be used as a pathfinder to prove the design Boeing and NASA's Commercial Crew Program worked together to develop is sound and can accomplish its missions.

For NASA, the main mission for Boeing's Starliner and the SpaceX Crew Dragon spacecraft is to re-establish an American launch capability for astronauts to use to reach the space station and make more use of its unique research environment. Experiments are conducted every day in orbit that will improve life on Earth and find answers to the challenges of deep space exploration so astronauts can undertake a successful journey to Mars in the future.

"Commercial crew is an essential component of our journey to Mars, and in 35 states, 350 American companies are working to make it possible for the greatest country on Earth to once again launch our own astronauts into space," said NASA Administrator Charles Bolden. "That's some impressive investment."

NASA expects to use the Starliner and Crew Dragon to take four crew members to the space station at a time, increasing the resident crew on the orbiting laboratory to seven at a time instead of the current six. By adding the workweek of a single new crew member to the capabilities of the space station, the amount of research time available to astronauts in orbit will double to about 80 hours a week.

Kennedy will be the home of Boeing's Commercial Crew Program, with other buildings at the center to be used as Boeing's Launch Control Center and for mission support.

"Kennedy Space Center has transitioned more than 50 facilities for commercial use. We have made improvements and upgrades to well-known Kennedy workhorses such as the Vehicle Assembly Building, mobile launcher, crawler–transporter and Launch Pad 39B in support of Orion, the SLS and Advanced Exploration Systems," said Robert Cabana, Kennedy's center director. "I am proud of our success in transforming Kennedy Space Center to a 21st century, multi-user spaceport that is now capable of supporting the launch of all sizes and classes of vehicles, including horizontal launches from the Shuttle Landing Facility, and spacecraft processing and landing."

Boeing officials say Kennedy was a natural choice given its expertise along the full range of spacecraft and rocket processing to launch and operations.

"When Boeing was looking for the prime location for its program headquarters, we knew Florida had a lot to offer from the infrastructure to the supplier base to the skilled work force," said Chris Ferguson, a former shuttle commander who now is deputy manager of operations for Boeing's Commercial Crew Program.

The Starliner will launch from Cape Canaveral Air Force Station's Space Launch Complex-41 on a United Launch Alliance, or ULA, Atlas V rocket. The crew access tower that will support astronauts and ground support teams before launch is being built a couple of miles away from the launch pad now and will be assembled adjacent to the current structures already at the pad. ULA will continue to operate the pad for Atlas V processing and launches during construction of the tower.

Although the infrastructure is coming together quickly, the first flight of the Starliner and Crew Dragon depends on a number of design and testing milestones for the entire space system before either one will be in a position to take its first flight test.

Working under contracts awarded last year, both Boeing and SpaceX agreed to conduct an orbital mission without a crew aboard for their respective spacecraft. Then each will launch a test flight, which includes astronauts, to demonstrate the spacecraft's ability to meet the demands of human-rated spaceflight. Following that mission, the spacecraft will be certified for operational missions carrying a full complement of crew to support the research work on the space station. And astronauts once again will be taking regular flights from Florida's Space Coast.

Watch Boeing Unveil the Starliner Processing Facility:
https://www.youtube.com/watch?v=hh5WaiZTK0k&feature=youtu.be

◄ The Boeing Company's newly named CST-100 Starliner commercial crew transportation spacecraft. Image credit: NASA

Engineers move the upper dome assembly of the CST-100 Starliner Structual Test Article onto a workstand inside the Commercial Crew and Cargo Processing Facility at NASA's Kennedy Space Center in Florida. Photo credit: Boeing

EXTREME MAKEOVER

C3PF EDITION

One of NASA's former space shuttle hangars, known as OPF-3, is being modernized to support Boeing's CST-100 spacecraft. Now called the Commercial Crew and Cargo Processing Facility, or C3PF, the high bay and adjoining work areas will be the production, assembly and processing home for this next generation human spacecraft.

EASTBOUND and Down...

The work platforms and other processing equipment traveled **2,718 miles** from Vandenberg Air Force Base to Kennedy Space Center where they were an integral part of shuttle mission preparations.

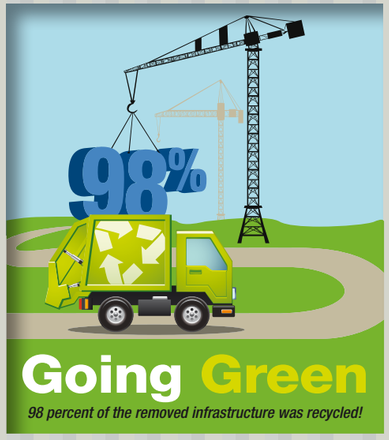
MORE THAN

129

SHUTTLE MAIN

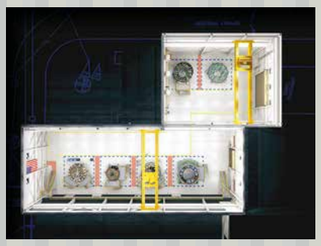
Engines

Processed



NEW OPEN FLOOR PLAN!

C3PF tops out at **78,000 sq. ft.** of processing area – the same space as **30 average American homes!**



Community Day

BY STEVEN SICELOFF

Photo credit: NASA/Amber Watson

The research, tools and theories of spaceflight and science took center stage Sept. 19 at the Kennedy Space Center Visitor Complex as children and families participated in the center's Community Day.

From an educator dazzling children by making clouds of nitrogen erupt from a bucket to robotics demonstrations to a helicopter and a Mine-Resistant Ambush-Protection, or MRAP, display, people had lots of competition for their curiosity. Not to mention a show from astronaut Bob Cabana, Kennedy's director, detailing his adventures in orbit assembling the first elements of the International Space Station.

"Anytime you can present science and technology and math to children it's worthwhile," said Mike Tillema, chief of Flight Operations at Kennedy. Answering questions about his helicopter and posing for photos with kids as they sat in the pilot seat, Tilemma said the students show interest from the moment they see the NASA logo-emblazoned Huey. "The young people's look — you can see that interest, the excitement."

The helicopter and MRAP armored vehicle parked by the rocket garden highlighted some of the infrastructure involved with operating NASA's primary spaceport. The helicopters are used in numerous operations year-round including wildlife surveys in addition to launch day work. The MRAPs are relatively new to the center and are being fitted for use as emergency evacuation vehicles for the next generation of human-rated rockets and spacecraft.

Inside the Space Shuttle Atlantis exhibit area, hundreds of visitors talked space lettuce with the scientists of Veggie whose experimentation produced the first space-grown vegetables consumed by astronauts in space. Children and their parents peered at the leafy plants that were grown on Earth under identical conditions to those on the station, but with gravity of course. The researchers also discussed the importance of growing even a small amount of food in space during long voyages such as those required of the astronauts who will make a journey to Mars.

It wasn't always the people that got the attention during the event. A few robots gathered crowds around them as they and their operators showed off abilities such as shooting basketballs. The robots are part of the FIRST competition that requires students to design and build their own machines for competitions.

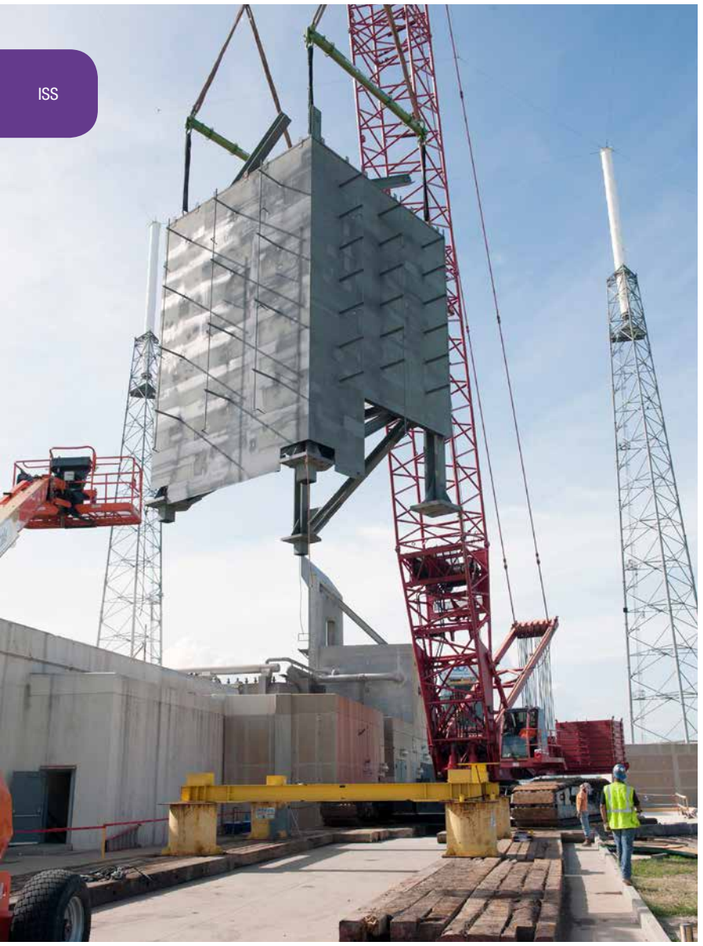
"The students are always excited as soon as soon as they see the robots," said James Rallo, a mentor for the Boeing ComBBAT 21 team. "They want to build the biggest, baddest robot. So we show them where to start and what it can lead to."

Students had plenty of chances to make things and take home creations, too. Paper airplanes and rockets along with scores of coloring pages and collector cards filled NASA shopping bags as the children made their way between the Community Day stations. All of Kennedy's programs were represented, along with NASA's variety of disciplines. Each stop usually ended with a similar message from agency experts: study science and math carefully and you can do this one day.

Year 1 Done

Commercial Crew Program marks a year of progress

BY STEVEN SICELOFF



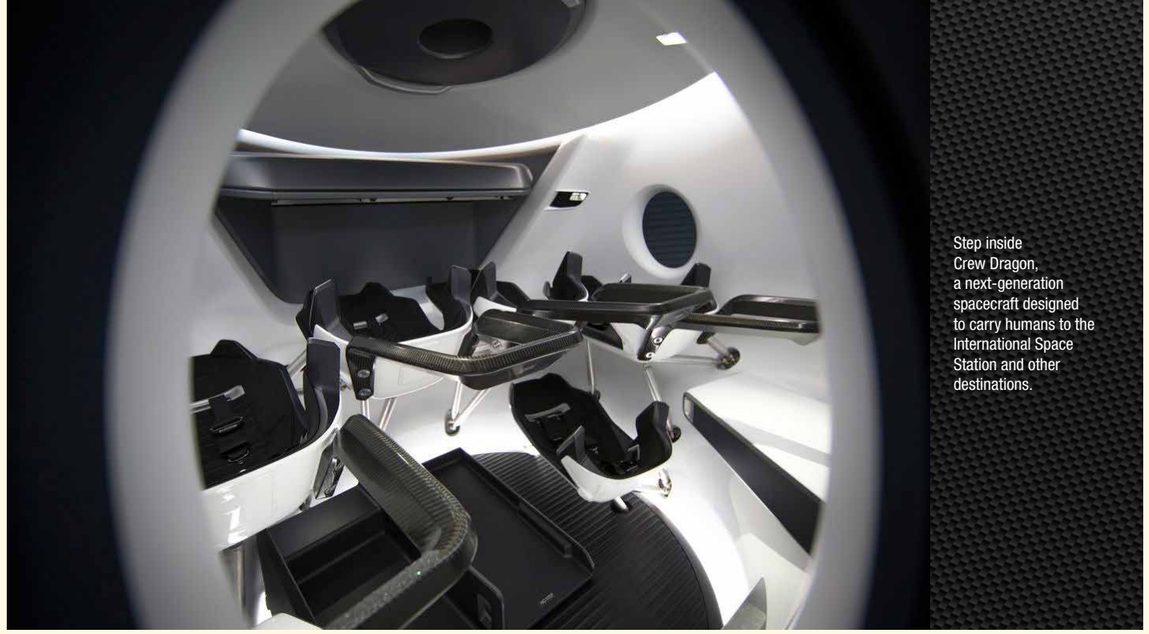
A crane lifts the first tier for placement at Space Launch Complex-41 at Cape Canaveral Air Force Station, Florida, to form the Crew Access Tower under construction by Boeing and United Launch Alliance. The steel structure is being built in seven pieces that will be stacked atop each other to form a 200-foot-tall tower complete with elevator, communications and power infrastructure, and an escape system. The tower will provide astronauts and ground support teams access to Boeing's CST-100 Starliner spacecraft, in development in partnership with NASA's Commercial Crew Program. Photo credit: NASA/Tony Gray

A year after awarding landmark contracts to Boeing and SpaceX to build a new generation of human-rated space systems, NASA's Commercial Crew Program has made great strides to re-establish America's capability to launch astronauts to the International Space Station, or ISS. Both companies are constructing the infrastructure needed to safely launch and operate crew space transportation systems. They also have offered detailed refinements to their designs and begun building the test vehicles that will be put through extreme analysis before their flight test regimens begin.

These accomplishments set the tone for the next two critical years that will culminate with operational missions carrying up to four astronauts to the ISS. They will increase the amount of time dedicated to research on the orbiting laboratory, solving the problems of long duration spaceflight so astronauts can make a successful journey to Mars in the future.

The contracts awarded Sept. 16, 2014 — known as CCtCap, short for Commercial Crew Transportation Capability — mark the latest in a series of development and certification efforts between NASA and the American aerospace industry since 2010. These contracts call for Boeing and SpaceX to build their systems and conduct flight tests with astronauts aboard in 2017. NASA will use the data gathered to certify the systems for operational missions to the space station.

As innovative as the technology is in the new generation of spacecraft, the process itself is an innovative approach to human spaceflight development. Under the Commercial Crew Program, NASA offered the American aerospace industry a chance to use its own expertise to rethink many aspects of human spaceflight while capitalizing on NASA's vast, specialized expertise.



Step inside Crew Dragon, a next-generation spacecraft designed to carry humans to the International Space Station and other destinations.

See inside the Crew Dragon, SpaceX's next-generation spacecraft designed to carry humans to the International Space Station and other destinations https://www.youtube.com/watch?v=xjSb_b4TtxI

The end result is shaping up to be the space transportation services NASA envisioned, along with a potential new high-tech industry for America that could open access to space for more people than ever before.

"It's hard to believe that it has been just a year since we announced the awards, and I think that is because we have made huge progress throughout the past year," said Phil McAlister, director of NASA's Commercial Spaceflight Development Division. "We are not done yet. We have perhaps some of the most difficult work ahead of us. It will take the collective efforts of the NASA and industry teams to meet the challenges ahead."

Boeing completed numerous wind tunnel runs and splash tests of Starliner, while SpaceX conducted intensive software analyses of the flight programming that will operate the spacecraft from launch to landing. The evaluation schedules were designed to build on each other with tests becoming increasingly complex.

> ***"All I can say is don't blink, because crew flight tests to the station in 2017 will be here before you know it, and we have a lot to do in that timeframe."***
>
> **Kathy Lueders**
> **Manager, Commercial Crew Program**

Boeing and SpaceX are in the midst of modifications along Florida's Space Coast where both companies will launch. Boeing recently opened its Starliner assembly and processing facility, which took advantage of existing infrastructure to modernize a former space shuttle orbiter processing facility at NASA's Kennedy Space Center in Florida. Boeing and United Launch Alliance also are stacking tiers of the Crew Access Tower nearby at Cape Canaveral Air Force Station's Space Launch Complex 41 where Atlas V rockets will lift Starliners into orbit. SpaceX is upgrading Kennedy's Launch Pad 39A to serve its Falcon 9 rocket and Crew Dragon. SpaceX also is nearing completion of a 300-foot-long horizontal processing hangar at the base of the pad, where spacecraft and rockets will be readied for flight.

Boeing is building a Structural Test Article of the Starliner that will include all the systems of an operational spacecraft. The test version will not go to low-Earth orbit, but will be put through numerous evaluations, including a pad abort test to see how it withstands conditions similar to what it would experience during a mission. The company also will conduct several tests of the parachute system that the Starliner will use to safely land at the end of a mission.

SpaceX has a series of propulsion systems tests coming up this year, along with an in-depth review of its plans for the launch pad to accommodate the unique needs of astronauts and ground support teams.

"Construction efforts on both launch pads will continue throughout the end of this year, while Boeing and SpaceX engineers and designers continue testing key systems, building hardware and refining their path to flight," said Kathy Lueders, manager of NASA's Commercial Crew Program. "All I can say is don't blink, because crew flight tests to the station in 2017 will be here before you know it, and we have a lot to do in that timeframe."

When the second anniversary of the contract award comes around next year, NASA and its partners expect to be in the home stretch, preparing for tests on the horizon and the promise of returning human launches to U.S. soil that much closer.

THE [REAL] MARTIANS

KSC employees on their Journey to Mars

LUKE ROBERSON & CLYDE POORE

We are designing, building and operating hazmat suits to fuel rockets to Mars.

MEREDITH CHANDLER

From the Red Planet to our planet, I am bringing space technologies down to earth.

TOM LIPPITT

I am working on ways to build launch and landing pads on Mars using materials from the planet.

GIOIA MASSA

I am working on growing plants in space to provide food and life support for astronauts going to Mars.

KURT LEUCHT

I am developing swarming robot technologies that can be used to efficiently gather valuable resources on Mars.

JESSICA PARSONS

I am bringing together the launch vehicle, the spacecraft and ground infrastructure to ensure we have the right requirements that will lead to a successful launch to Mars.

ROB MUELLER

I am developing technologies to extract water from the soil on Mars.

DREW SMITH

I am developing excavation technologies to be used on Mars.

ED TUGG

I am ensuring rockets carrying precursor robots to Mars launch successfully.

RAVI MARGASAHAYAM

I am ensuring the safety of payloads and launch vehicles in support of Mars-bound astronauts.

Photo credit: NASA/Glenn Benson

REEL TO REAL

Nine real NASA technologies in 'The Martian'

The film "The Martian" takes the work NASA and others have done exploring Mars and extends it into fiction set in the 2030s, when NASA astronauts are regularly traveling to Mars and living on the surface.

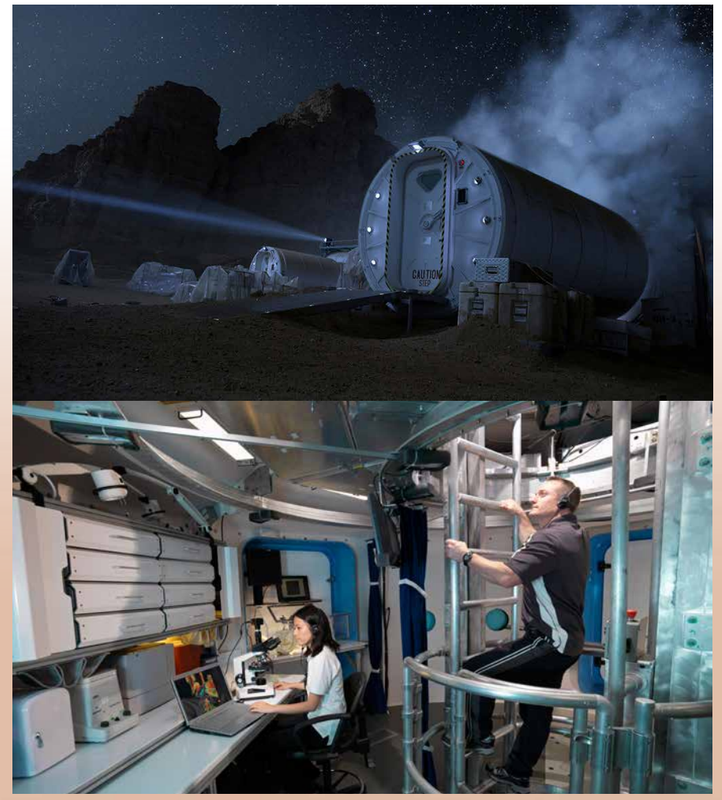
NASA has collaborated on this film with 20th Century Fox Entertainment, providing guidance on production design and technical consultants, including Jim Green, director of planetary science, and Dave Lavery, program executive for solar system exploration. Astronaut Tracey Caldwell-Dyson also provided advice and guidance to actress Jessica Chastain as she prepared for her role in the film.

Although the action takes place 20 years in the future, NASA already is developing many of the technologies that appear in the film.

Habitat

On the surface of Mars, Watney spends a significant amount of time in the habitation module — the Hab — his home away from home. Future astronauts who land on Mars will need such a home to avoid spending their Martian sols (a sol is a Martian day) lying on the dust in a spacesuit.

At Johnson Space Center, crews train for long-duration deep space missions in the Human Exploration Research Analog, or HERA. HERA is a self-contained environment that simulates a deep-space habit. The two-story habitat is complete with living quarters, workspaces, a hygiene module and a simulated airlock. Within the module, test subjects conduct operational tasks, complete payload objectives and live together for 14 days (soon planned to increase to up to 60 days), simulating future missions in the isolated environment. Astronauts have recently used the facility to simulate International Space Station, or ISS, missions. These research analogs provide valuable data in human factors, behavioral health and countermeasures to help further NASA's understanding on how to conduct deep space operations.



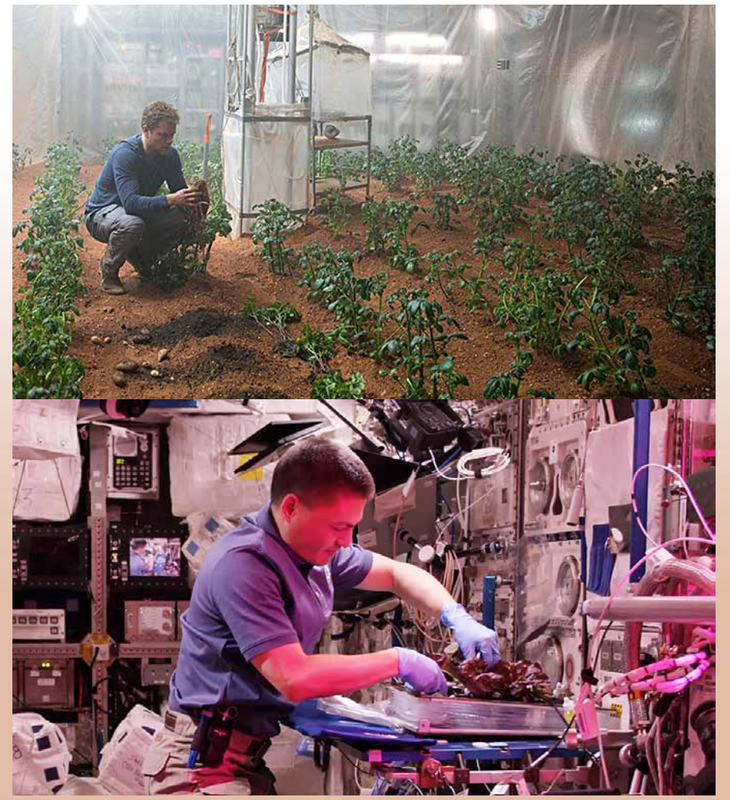
Top: An artificial living habitat (Hab) is necessary to facilitate human exploration of the planet Mars in "The Martian." Photo credit: Twentieth Century Fox/NASA

Bottom: The Human Exploration Research Analog (HERA) at NASA's Johnson Space Center. Image credit: Fox/NASA

Plant Farm

Today, astronauts on the ISS have an abundance of food delivered to them by cargo resupply vehicles, including some from commercial industries. On Mars, humans would not be able to rely on resupply missions from Earth — even with express delivery they would take at least nine months. For humans to survive on Mars, they will need a continuous source of food. They will need to grow crops.

Watney turns the Hab into a self-sustaining farm in "The Martian," making potatoes the first Martian staple. Today, in low-Earth orbit, lettuce is the most abundant crop in space. Aboard the ISS, Veggie is a deployable fresh-food production system. Using red, blue and green lights, Veggie helps plants grow in pillows, small bags with a wicking surface containing media and fertilizer, to be harvested by astronauts. In 2014, astronauts used the system to grow "Outredgeous" red romaine lettuce and just recently sampled this space-grown crop for the first time. This is a huge step in space farming, and NASA is looking to expand the amount and type of crops to help meet the nutritional needs of future astronauts on Mars.



Top: In a scene from "The Martian," astronaut Mark Watney employs some ingenious methods to plant crops on Mars. Peter Mountain/NASA

Bottom: Real-life NASA astronaut Kjell Lindgren harvests lettuce grown from the Veggie experiment while on board the International Space Station. Photo credit: Peter Mountain/NASA

Water Recovery

There are no lakes, rivers or oceans on the surface of Mars, and sending water from Earth would take more than nine months. Astronauts on Mars must be able to create their own water supply. The Ares 3 crew does not waste a drop on Mars with their water reclaimer, and Watney needs to use his ingenuity to come up with some peculiar ways to stay hydrated and ensure his survival on the Red Planet.

On the International Space Station, no drop of sweat, tears, or even urine goes to waste. The Environmental Control and Life Support System recovers and recycles water from everywhere: urine, hand washing, oral hygiene, and other sources. Through the Water Recovery System, or WRS, water is reclaimed and filtered, ready for consumption. One astronaut simply put it, "Yesterday's coffee turns into tomorrow's coffee."

Liquid presents some tricky problems in space. The WRS and related systems have to account for the fact that liquids behave very differently in a microgravity environment. The part of the WRS that processes urine must use a centrifuge for distillation, since gases and liquids do not separate like they do on Earth.

NASA is continuing to develop new

http://www.nasa.gov/feature/nine-real-nasa-technologies-in-the-martian

NASA is giving university and college students an opportunity to be part of the agency's journey to Mars with the Breakthrough, Innovative, and Game-changing, or BIG, Idea Challenge. For more information about the challenge, and details on how to apply, visit: http://bigidea.nianet.org

technologies for water recovery. Research is being conducted to advance the disposable multi-filtration beds (the filters that remove inorganic and non-volatile organic contaminants) to be a more permanent component to the system. Brine water recovery would reclaim every drop of the water from the "bottoms product" leftover from urine distillation. For future human-exploration missions, crews would be less dependent on any resupply of spare parts or extra water from Earth.

The technology behind this system has been brought down to Earth to provide clean drinking water to remote locations and places devastated with natural disasters.

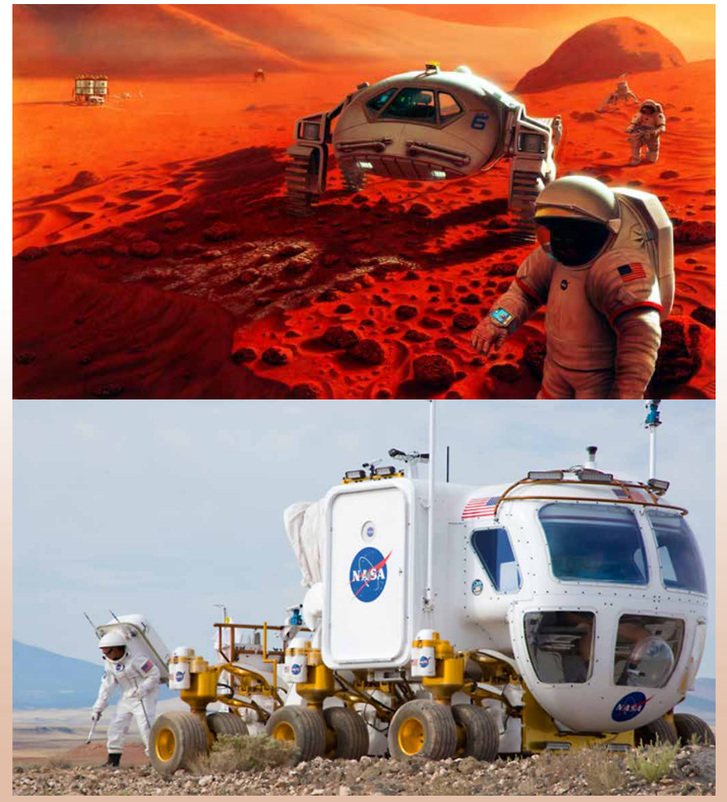
Oxygen Generation

Food, water, shelter: three essentials for survival on Earth. But there's a fourth we don't think about much, because it's freely available: oxygen. On Mars, Watney can't just step outside for a breath of fresh air to survive, he has to carry his own supply of oxygen everywhere he goes. But first he has to make it. In his Hab he uses the "oxygenator," a system that generates oxygen using the carbon dioxide from the Mars Ascent Vehicle, or MAV, fuel generator.

On the International Space Station, the astronauts and cosmonauts have the Oxygen Generation System, which reprocesses the atmosphere of the spacecraft to continuously provide breathable air efficiently and sustainably. The system produces oxygen through a process called electrolysis, which splits water molecules into their component oxygen and hydrogen atoms. The oxygen is released into the atmosphere, while the hydrogen is either discarded into space or fed into the Sabatier System, which creates water from the remaining byproducts in the station's atmosphere.

Oxygen is produced at a more substantial rate through a partially closed-loop system that improves the efficiency of how the water and oxygen are used. NASA is working to recover even more oxygen from byproducts in the atmosphere to prepare for the journey to Mars.

2015 marks 50 years of successful NASA missions to Mars starting with Mariner 4 in 1965. Since then, a total of 15 robotic missions led by various NASA centers have laid the groundwork for future human missions to the Red Planet. The journey to Mars continues with additional robotic missions planned for 2016 and 2020, and human missions in the 2030s.
https://www.youtube.com/watch?v=pwipxdQ74pU



Top: This artist's concept of a future Mars mission shows astronauts near a lander on the Red Planet. Photo credit: NASA

Bottom: NASA is advancing habitat and spacesuit technology to explore Mars. Photo credit: NASA

Mars Spacesuit

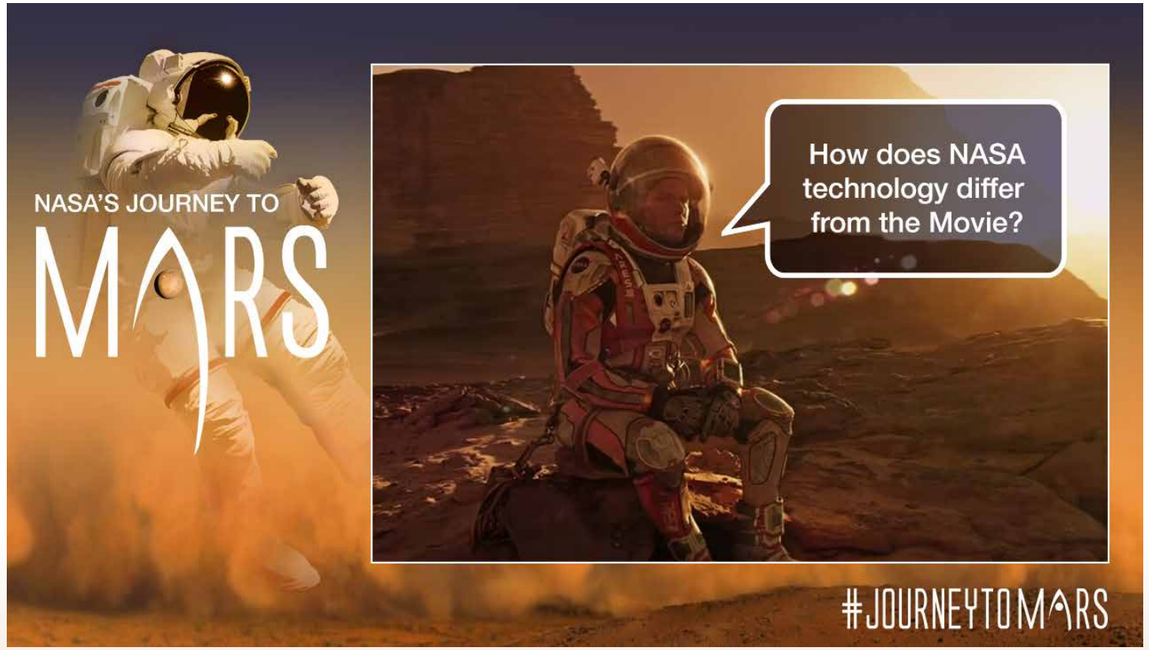
The Martian surface is not very welcoming for humans. The atmosphere is cold and there is barely any breathable air. An astronaut exploring the surface must wear a spacesuit to survive outside of a habitat while collecting samples and maintaining systems.

Mark Watney spends large portions of his Martian sols working in a spacesuit. He ends up having to perform some long treks on the surface, so his suit has to be flexible, comfortable, and reliable.

NASA is currently developing the technologies to build a spacesuit that would be used on Mars. Engineers consider everything from traversing the Martian landscape to picking up rock samples.

The Z-2 and Prototype exploration Suit, NASA's new prototype spacesuits, help solve unique problems to advance new technologies that will one day be used in a suit worn by the first humans to set foot on Mars. Each suit is meant to identify different technology gaps — features a spacesuit may be missing — to complete a mission. Spacesuit engineers explore the tradeoff between hard composite materials and fabrics to find a nice balance between durability and flexibility.

One of the challenges of walking on Mars will be dealing with dust. The red soil on Mars could affect the astronauts and systems inside a spacecraft if tracked in after a spacewalk. To counter this, new spacesuit designs feature a suitport on the back, so astronauts can quickly hop in a spacecraft while the suit stays outside, keeping it clean indoors.



Rover

Once humans land on the surface of Mars, they must stay there for more than a year, while the planets move into a position that will minimize the length of their trip home. This allows the astronauts plenty of time to conduct experiments and explore the surrounding area, but they won't want to be limited to how far they can go on foot. Astronauts will have to use robust, reliable and versatile rovers to travel farther.

In "The Martian," Watney takes his rover for quite a few spins, and he even has to outfit the vehicle with some unorthodox modifications to help him survive.

On Earth today, NASA is working to prepare for every encounter with the Multi-Mission Space Exploration Vehicle, or MMSEV. The MMSEV has been used in NASA's analog mission projects to help solve problems that the agency is aware of and to reveal some that may be hidden. The technologies are developed to be versatile enough to support missions to an asteroid, Mars, its

https://www.youtube.com/watch?v=tCHAr5uyHV4&feature=youtu.be

Find out more about what NASA is doing at http://www.nasa.gov/realmartians

moons and other missions in the future. NASA's MMSEV has helped address issues like range, rapid entry/exit and radiation protection. Some versions of the vehicle have six pivoting wheels for maneuverability. In the instance of a flat tire, the vehicle simply lifts up the bad wheel and keeps on rolling.

Ion Propulsion

Slow and steady wins the race, and ion propulsion proves it.

In "The Martian," the Ares 3 crew lives aboard the Hermes spacecraft for months as they travel to and from the Red Planet, using ion propulsion as an efficient method of traversing through space for more than 280 million miles. Ion propulsion works by electrically charging a gas such as argon or xenon and pushing out the ions at high speeds, about 200,000 mph. The spacecraft experiences a force similar to that of a gentle breeze, but by continuously accelerating for several years, celestial vessels can reach phenomenal speeds. Ion propulsion also allows the spacecraft to change its orbit multiple times, then break away and head for another distant world.

This technology allows modern day spacecraft like NASA's Dawn spacecraft to minimize fuel consumption and perform some crazy maneuvers. Dawn has completed more than five years of continuous acceleration for a total velocity change around 25,000 mph, more than any spacecraft has accomplished on its own propulsion system. Along the way, it has paid humanity's first visits to the dwarf planet Ceres and the asteroid Vesta.

Solar Panels

There are no gas stations on Mars. No power plants. Virtually no wind. When it comes to human missions to the Red Planet, solar energy can get the astronauts far. The Hermes spacecraft in the book uses solar arrays for power, and Mark Watney has to use solar panels in some unconventional ways to survive on Mars.

On the International Space Station, four sets of solar arrays generate 84 to 120 kilowatts of electricity — enough to power more than 40 homes. The station doesn't need all that power, but the redundancy helps mitigate risk in case of a failure. The solar power system aboard the space station is very reliable, and has been providing power safely to the station since its first crew in 2000.

Orion, NASA's spacecraft that will take humans farther than they've ever gone before, will use solar arrays for power in future missions. The arrays can gather power while in sunlight to charge onboard lithium-ion batteries. In case no sunlight is available — for instance, if Orion were to go behind the moon — there would still be plenty of power to allow it to operate.

RTG

For more than four decades, NASA has safely used Radioisotope Thermoelectric Generators, or RTGs, to provide electrical power for two dozen space missions, including Apollo missions to the moon. Spacecraft such as the Mars rover Curiosity and the upcoming Mars 2020 rover use an updated, next-generation model for electrical power.

RTGs are "space batteries" that convert heat from the natural radioactive decay of plutonium-238 into reliable electrical power. The RTG on Curiosity generates about 110 watts of power or less — slightly more than an average light bulb uses.

In "The Martian," the crew buries the plutonium-based RTG power source for the Mars Ascent Vehicle far away from the Hab in case of radioactive leakage. To prevent any leak, as suggested in the movie, Plutonium-238 has several layers of strong, advanced materials that protect against release even in severe accidents. The RTG mostly emits alpha radiation, which can only travel a few inches in the air and does not penetrate clothing or human skin. It could only affect human health if it were broken into very fine particles or vaporized, and inhaled or ingested. The isotope is manufactured in a ceramic form, so accidentally inhaling or ingesting it is unlikely, particularly as it does not dissolve in liquids.

In reality, the natural radiation environment on Mars is more extreme than the radiation produced from an RTG. Ionizing radiation raining down on Mars from space is far more hazardous to human health. Current Mars missions are analyzing the Martian radiation environment so that mission planners can design protection systems for future astronauts.

Future explorers will need assured, reliable and durable power sources for survival in place before they arrive. Power system options might include a mix of more efficient radioisotope power systems, solar power, fuel cells and nuclear fission.

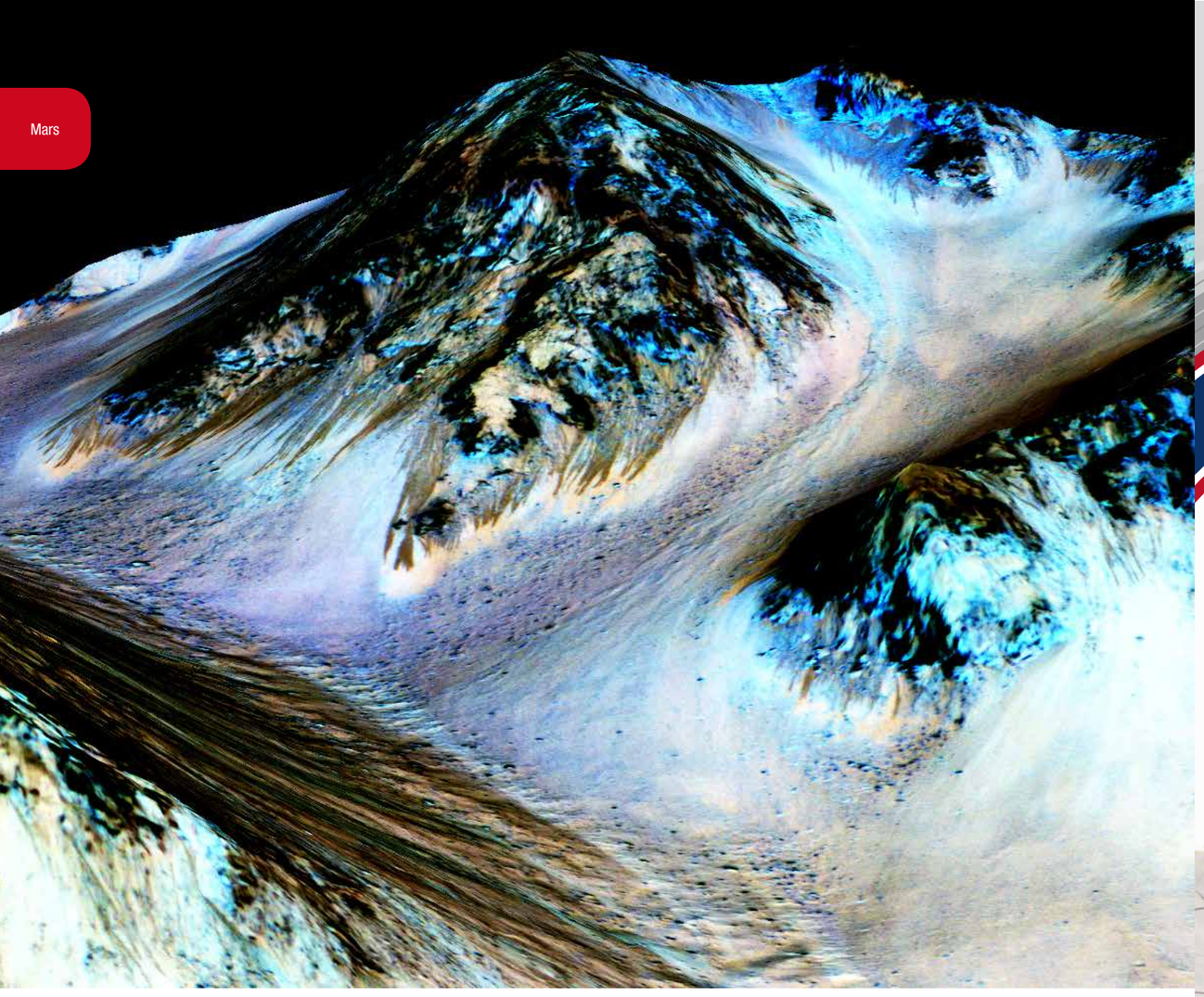
The Journey to Mars

Human spaceflight is a dangerous business. NASA is working to send humans to Mars in the 2030s, but there are many milestones to accomplish to ensure that astronauts come back to Earth safely. Astronaut Scott Kelly, currently aboard the International Space Station for one year, put it perfectly: space is hard. The margin for error is virtually zero for every aspect of spaceflight. However, we learn so much along the journey to Mars that furthers our understanding of the universe, and everything we do and learn is brought right back to Earth to benefit humanity.

Ridley Scott, director of the 20th Century Fox film "The Martian," based on author Andy Weir's book of the same name, reflects on the long-term personal and wide-ranging human fascination with Mars and how NASA's exploration of the Red Planet is helping to turn science fiction into science fact: https://www.youtube.com/watch?v=nTAhl1Ud5QY

Watch 'The Martian' Star Matt Damon Discuss NASA's Journey to Mars: https://www.youtube.com/watch?v=jTbVCgAsmks

Actor Matt Damon, who stars as NASA Astronaut Mark Watney in the film "The Martian," smiles after having made his hand prints in cement at the Jet Propulsion Laboratory, or JPL, Mars Yard, while Mars Science Lab Project Manager Jim Erickson, left, and NASA Astronaut Drew Feustel look on Aug. 18 at JPL in Pasadena, California. While at JPL Damon met with NASA scientists and engineers who served as technical consultants on the film. The movie portrays a realistic view of the climate and topography of Mars, based on NASA data, and some of the challenges NASA faces as we prepare for human exploration of the Red Planet in the 2030s. Photo credit: NASA/ Bill Ingalls



Water is flowing on Mars

Dark, narrow streaks on Martian slopes such as these at Hale Crater are inferred to be formed by seasonal flow of water on contemporary Mars. The streaks are roughly the length of a football field.Photo credit: NASA/JPL/University of Arizona.

New findings from NASA's Mars Reconnaissance Orbiter, or MRO, provide the strongest evidence yet that liquid water flows intermittently on present-day Mars.

Using an imaging spectrometer on MRO, researchers detected signatures of hydrated minerals on slopes where mysterious streaks are seen on the Red Planet. These darkish streaks appear to ebb and flow over time. They darken and appear to flow down steep slopes during warm seasons, and then fade in cooler seasons. They appear in several locations on Mars when temperatures are above minus 10 degrees Fahrenheit, and disappear at colder times.

"Our quest on Mars has been to 'follow the water,' in our search for life in the universe, and now we have convincing science that validates what we've long suspected," said John Grunsfeld, astronaut and associate administrator of NASA's Science Mission Directorate in Washington. "This is a significant development, as it appears to confirm that water — albeit briny — is flowing today on the surface of Mars."

Read more at http://go.nasa.gov/1GctAoT

National Aeronautics and Space Administration

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GROUND SYSTEMS DEVELOPMENT & OPERATIONS

Javan Banks

Project Manager, IT Project Management Office

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KENNEDY SPACE CENTER

Exploration Begins Here

SEEDS of Inspiration

Student challenge may cultivate solutions for NASA

BY AMANDA GRIFFIN

Many students find solace in knowing they are able to find answers to odd-numbered problems by looking in the back of their textbooks. However, for thousands of students and teachers, not only are the answers not in the back of the book — the answers don't even exist.

On Sept. 26, Kennedy Space Center's Dr. Gioia Massa and Trent Smith, both involved with NASA's Veggie project, met with teachers who are participating in the Fairchild Challenge — an environmental science competition focused on STEM. According to Massa, a project scientist, she was approached by Fairchild after the director, Carl Lewis, saw a video of her and NASA's work with Veggie — a plant growth chamber currently on the International Space Station to help figure out how to best grow plants in space.

The challenge spans the academic year, and targets middle- and high-school students in south Florida. This year's challenge explores the connection among plants, human civilization and the environment and is titled Voyages of Plants.

"The idea behind the NASA challenge is that just like the Polynesians had to decide what plants to take in their canoes when they ventured on one way trips to settle distant islands, so too, future space explorers will have to decide what crops they take when they settle other worlds," Massa explained.

Massa and Smith brought in NASA educators Dr. Wanda Jones and Dr. Lester Morales and the team drafted the challenge during the summer.

"The idea during all our discussions with Fairchild was to conduct citizen science with the students to test plants that might be grown in Veggie and future exploration missions," Massa said. "With thousands of students involved, we will have tremendous power to test numerous different plants and the students may, in fact, find new, great candidates that we never considered."

As scientists, Massa said they hope to gain new ideas for types of crops and growing techniques that will deliver large amounts of nutritious and appealing produce for the astronauts. She added, "We also hope to gain a pipeline of students interested in conducting space biology research on food production."

Massa, Smith and educators at KSC and Fairchild will spend the next year interacting and tweeting with students, providing workshops to teachers to help them conduct the activities and to answer any questions along the way. The challenge is set to be complete next April.

Smith, Veggie project manager, really connected to this challenge. "For me, when the Fairchild team mentioned the Polynesian explorers, it so reminded me of what we one day will do with Mars. And personally, the reality of actually performing real experiments where the answer is not in the back of the book is so very exciting, and in my view, really sparks curiosity and the love of science for students. It did for me. "

NASA plans to grow food on future spacecraft and on other planets as a food supplement for astronauts. Fresh food, such as vegetables, provide essential vitamins and nutrients that will help enable sustainable deep space pioneering. Image credit: NASA

JOURNEY TO MARS

HUBBLE

INTERNATIONAL SPACE STATION

SPACE LAUNCH SYSTEM (SLS)

ORBITERS

LANDERS

SCIENCE

EXPLORATION

TECHNOLOGY

PHOBOS

DEIMOS

ORION

SOLAR ELECTRIC PROPULSION

ASTEROID REDIRECT MISSION

IN-SPACE HABITAT

MARS TRANSFER SPACECRAFT

COMMERCIAL CARGO AND CREW

NASA is developing the capabilities needed to send humans to an asteroid by 2025 and Mars in the 2030s. Engineers and scientists around the country are working hard to develop the technologies astronauts will use to one day live and work on Mars, and safely return home from the next giant leap for humanity.

MAX Velocity

Space Launch System umbilical testing underway with simulated rocket launch

BY LINDA HERRIDGE

When NASA's powerful rocket, the Space Launch System, or SLS, is prepared for launch, it will be rolled out to the launch pad aboard a mobile launcher. The launcher will be equipped with a number of lines, called umbilicals, that connect to the rocket and Orion spacecraft to provide power, communications, coolant and fuel. In preparation for the rocket's first launch on Exploration Mission-1, or EM-1, engineers are conducting a series of tests on the umbilical system, including a simulated rocket launch.

The tower on the mobile launcher contains several of these umbilicals, the first of which to be tested is the Orion service module umbilical, OSMU. This umbilical will be located high on the tower and will transfer liquid coolant for the electronics and air for the Environmental Control System, or ECS, prior to launch to the Orion service module that houses critical systems that support the spacecraft.

The Ground Systems Development and Operations, or GSDO, Program is coordinating and overseeing the tests at the Launch Equipment Test Facility, or LETF, at Kennedy Space Center. The LETF will verify the 15-foot umbilical is functioning properly before it is installed on the mobile launcher early next year. During testing, engineers will supply water for the electronics and nitrogen to simulate the ECS.

"This is the second umbilical in a series of tests that we'll be performing for GSDO," said Martin Grashik, mechanical systems test engineer. "It is the first umbilical for the tower and is more technically complex, and more challenging to test, than anything we've done for GSDO so far."

During the first in the series of tests for this umbilical, the OSMU will be attached to a Vehicle Motion Simulator that can simulate all expected launch vehicle motions from rollout through about the first half-

> *"It's a new test for us, simulating the velocity of a rocket launch."*
>
> **Jeff Crisafulli**
> **NASA LETF Manager**

second of launch, when the umbilical is disconnected.

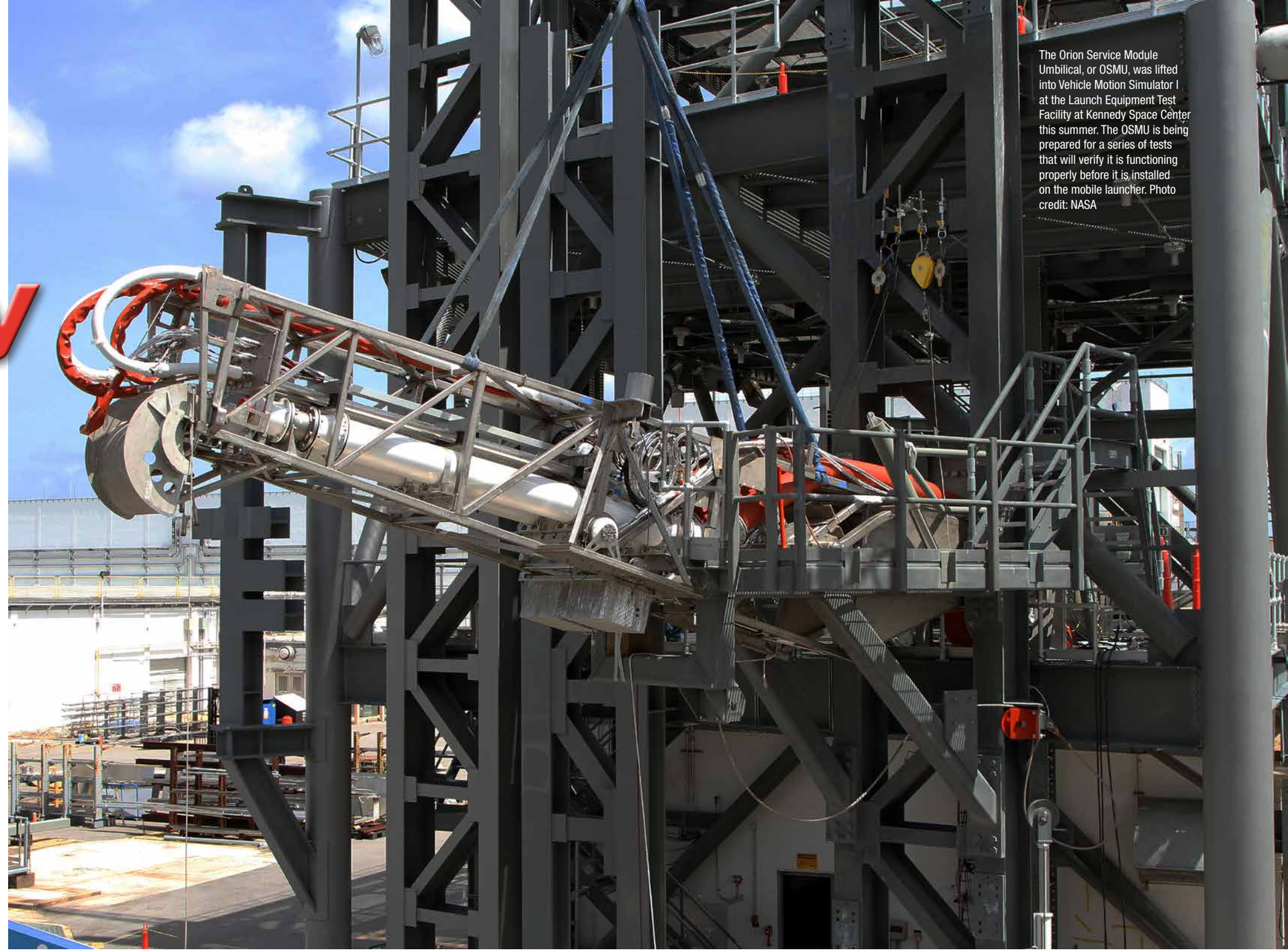
The team also will check the OSMU umbilical interfaces for functionality. They will confirm the mechanisms that raise and lower the umbilical are working. Additional tests will evaluate the range of motion on all of the hoses leading from the umbilical and verify the devices that retract the quick-disconnect plates. Engineers also will assess the fire suppression system and adjust the water spray nozzles.

Then, the OSMU will be put through the paces of a simulated rocket launch. Engineers will attach the umbilical to a replicated section of the Orion Service Module on the simulator, and the OSMU will experience the maximum velocity, up to 120 inches per second, during the launch simulation.

"It's a new test for us, simulating the velocity of a rocket launch," said Jeff Crisafulli, NASA LETF manager. "Using two vehicle motion simulators also has significantly reduced testing time, allowing the earliest possible delivery to the mobile launcher for final installation."

This series of tests follows the testing of the first of two aft skirt electrical umbilicals, or ASEU. Testing of the OSMU will continue through September when the umbilical will be reconfigured for further testing, and then readied for delivery to the mobile launcher in early 2016. After the OSMU testing, the team will continue testing additional umbilicals that also will be installed on the mobile launcher.

GSDO is performing all of this testing now to ensure that the OSMU and the other umbilicals will be ready for installation on the mobile launcher tower as NASA prepares for the first integrated launch of SLS and Orion on Exploration Mission-1.



The Orion Service Module Umbilical, or OSMU, was lifted into Vehicle Motion Simulator I at the Launch Equipment Test Facility at Kennedy Space Center this summer. The OSMU is being prepared for a series of tests that will verify it is functioning properly before it is installed on the mobile launcher. Photo credit: NASA

KSC Scenes

Jeff Bezos, founder and CEO of Blue Origin, speaks during an event at Space Launch Complex 36 at Cape Canaveral Air Force Station in Florida for the announcement that Blue Origin will build rockets at Exploration Park at NASA's Kennedy Space Center and launch them from SLC-36 at the Cape. Looking on is Rick Scott, Florida governor.

Photo credit: NASA/Kim Shiflett

SOMBER SUPPORT

World Trade Center I-beam unveiled at 9/11 memorial

BY ANNA HEINEY

A one-ton section of solid steel I-beam salvaged from the ruins of the World Trade Center in New York City now rests permanently atop twin concrete pedestals at Kennedy Space Center's Fire Station No. 1. It was dedicated during a ceremony on the 14th anniversary of the Sept. 11, 2001, attacks, which claimed the lives of nearly 3,000 people. Of those, 343 were fire-rescue personnel.

The beam arrived at Kennedy in August after a two-day journey that began at JFK International Airport in New York. A five-person Artifact Escort Team from Kennedy Space Center's Fire Rescue traveled along with it to ensure its safe arrival at the Florida spaceport. The memorial remained draped until its ceremonial unveiling.

Lt. James Dumont of KSC Fire Rescue explained the symbolism behind each element of the memorial.

"The flagpole serves as a reminder of our nation's enduring commitments to freedom, justice and liberty. The shield recalls the 343 fire rescue personnel who made the ultimate sacrifice, giving their lives trying to spare the lives of others," Dumont said.

The twin concrete bases represent the twin towers of the World Trade Center, and of course, those form the foundation for the memorial's centerpiece: a steel beam from the World Trade Center."

The steel beam's presence at Kennedy is the result of a four-year effort. Kennedy's Fire Rescue Services worked closely with NASA leadership, including Center Director Bob Cabana, the Transport Workers Union of America and the Port Authority of New York.

Even after the team received word that Kennedy had been awarded a piece, another issue remained — transporting it from New York to Florida. American Airlines' cargo team custom-built a wooden travel container to hold the beam during the trip.

The Artifact Escort Team finally saw the beam in person in New York. Labeled G-0063, the 7-foot-long piece now belongs to the Transport Workers Union Local 525.

"I had seen a photo of it in an email. We saw it in person for the first time on Aug. 12. It was a very solemn moment on the tarmac at JFK International Airport," recalled Fire Chief Richard Anderson of the Centerra Group.

The journey took them from New York to Philadelphia, then to Miami. At that point the container was placed in Dumont's pickup truck for the drive to the space center.

People from communities along the way lined roadways and overpasses in a show of respect as the caravan made its way north. Brevard County Sheriff's Office provided an escort for the final leg of the journey across the Space Coast.

The lessons of Sept. 11 extend to NASA and Kennedy Space Center.

"Our country's first responders are heroes, like our astronauts, because every time they suit up, they put on their uniform to go out on their mission, they accept the fact that their life could be put at risk," Kennedy's Associate Director Kelvin Manning said.

As years pass, less of the workforce has a personal connection or memory of the events of Sept. 11, but it's important to remain vigilant — and to be inspired by the dedication of those who have given their lives so others may live.

"The memorial will be a daily reminder," Anderson said. "We don't want anybody to forget their sacrifice."

> ***"Our country's first responders are heroes, like our astronauts, because every time they suit up, they put on their uniform to go out on their mission, they accept the fact that their life could be put at risk."***
>
> **Kelvin Manning**
> **Associate Director, Kennedy Space Center**

An honor guard folds an American flag during the dedication service for a memorial to the 343 first responder victims of the Sept. 11, 2001, terror attacks at Fire Station No. 1 at NASA's Kennedy Space Center on Sept. 11, 2015. Credits: NASA/Kim Shiflett

Workers monitor the progress as a crane lowers the Orion crew module transportation cover away from the crew and service module, or CSM, pathfinder during an installation demonstration using the CSM pathfinder and the Exploration Flight Test-1 CSM transportation cover in the transfer aisle of the Vehicle Assembly Building at Kennedy Space Center. Use of the pathfinder will allow the Ground Systems Development and Operations, or GSDO, Program to evaluate the cover installation and removal operation and interface with the CSM in order to provide any improvements for the final cover design. The demonstration also will allow GSDO to evaluate the necessary procedures for future Orion operations in the Multi-Payload Processing Facility and the Launch Abort System Facility, crane height, and provide workers with handling and operational experience. Orion will next launch atop NASA's Space Launch System rocket on Exploration Mission-1.

Photo credit: NASA/Kim Shiflett

Innovation & Exploration Through the Ages

1. **Carthage: 814 B.C.-146 B.C.** — Hanno the Navigator, a Carthaginian mariner, explored the western coast of Africa.
2. **Phoenicia: 600 B.C.** — Phoenicians developed sea routes around the entire Mediterranean and into the Red Sea and the Indian Ocean.
3. **Greece: 500-200 B.C.** — Greeks developed trade routes in the Mediterranean using the length of the day (corrected for the time of the year) to estimate latitude.
4. **Norway: 900 A.D.-1430 A.D.** — Vikings explored and colonized Iceland, Greenland and Newfoundland. About 1002 A.D. Leif Erikson reached North America 500 years before Columbus.
5. **China: 1405-1433** – A massive Chinese armada of nine-mast ships navigated west to Ceylon, Arabia and East Africa. The leading Chinese pioneer was Zheng He who established a broad web of valuable trading routes from Taiwan to the Persian Gulf.
6. **Spain: 1492** — Christopher Columbus reached America looking for a sea route to the Indies. He discovered various lands and islands and established a colony on Hispaniola.
7. **Spain: 1509-1519** — Spanish explorer Juan Ponce de León became the first Governor of Puerto Rico. Ponce de León led the first European expedition to Florida, which he named.
8. **Portugal: 1519 and 1522** — Ferdinand Magellan's ships circumnavigate the world.
9. **Plymouth Bay Colony: 1620** — Pilgrims sail from England to establish a permanent settlement that is now Plymouth, Massachusetts.
10. **Great Britain: 1768 to 1780** — James Cook explored the southern parts of the oceans looking for the southern continent.
11. **Western United States: 1804 and 1806** — Capt. Meriwether Lewis and 2nd Lt. William Clark conducted an expedition to explore what would become the western portion of the new nation.
12. **Kitty Hawk, North Carolina: Dec. 17, 1903** — Orville and Wilbur Wright made the first controlled, powered heavier-than-air flight.
13. **Worcester, Massachusetts: March 16, 1926** — Robert Goddard successfully launched the world's first liquid propellant rocket.
14. **North Pole: May 9, 1926** — U.S. Navy Rear Admiral Richard Byrd and pilot Floyd Bennett completed the first flight over the North Pole.
15. **New York, New York: May 1927** — Charles Lindbergh becomes the first to make a transatlantic flight traveling from Roosevelt Field in New York to Le Bourget Airport in Paris.
16. **Newfoundland, Canada: June 1928** — Aviatrix Amelia Earhart became the first woman to fly across the Atlantic Ocean.
17. **United States: July 10-14, 1938** — Howard Hughes set an aviation record by completing a flight around the world in just 3 days, 19 hours, 17 minutes.
18. **Ft. Bliss in El Paso, Texas: 1945-1949** — Wernher von Braun's Rocket Team began America's early exploration of the edges of space from White Sands, New Mexico.
19. **Muroc Air Force Base (now Edwards Air Force Base), California: Oct. 14, 1947** — U.S. Air Force pilot Chuck Yeager flew the X-1 rocket plane faster than the speed of sound –- about 768 mph
20. **Baikonur Cosmodrome, Kazakhstan, Soviet Union: Oct. 3, 1957** – The world's first Earth satellite, Sputnik 1, is launched into orbit.
21. **Cape Canaveral Air Force Station, Florida: Jan. 31, 1958** — America's first satellite Explorer 1 launched into orbit around the Earth.
22. **Baikonur Cosmodrome, Kazakhstan, Soviet Union: April 12, 1961** — Cosmonaut Yuri Gagarin becomes the first human to fly in space, completing one orbit of the Earth aboard the Vostok 1 spacecraft.
23. **Cape Canaveral Air Force Station, Florida: May 5, 1961** — Astronaut Alan Shepard is launched as the first American in space aboard a Mercury spacecraft he named "Freedom 7."
24. **Kennedy Space Center, Florida – July 16, 1969** — Apollo 11 is launched with astronauts Neil Armstrong, Mike Collins and Buzz Aldrin aboard for the first moon landing.

Why Do We Explore?

Human desire for exploration leads to discovery

BY BOB GRANATH

Throughout history, humankind has shared an innate trait — the desire to explore. Prehistoric men and women may have stood curiously at the opening to caves and wondered what was over the next hill. Centuries later, a teenager in New England envisioned a trip to a distant planet.

In the autumn of 1899, 17-year-old Robert Goddard climbed a tall cherry tree at his home in Worcester, Massachusetts. As he gazed into the sky, Goddard recalled how he was inspired by the works of authors such as H.G. Wells.

"I looked toward the fields at the east," he said, "imagining how wonderful it would be to make some device which had even the possibility of ascending to Mars."

According to the Merriam-Webster Dictionary, to explore is to "conduct a systematic search or to travel over new territory for adventure or discovery."

Goddard was not alone in his desire. Over millennia, human ventures have led to navigating the seas, discovering new lands, conquest of the skies and, now, the exploration of space.

In his high school graduation address, Goddard expressed his belief that a vision for the future can be captured.

"It has often proved true that the dream of yesterday is the hope of today and the reality of tomorrow," he said.

Goddard dedicated his life to inventing that "device" that could, one day, reach the Red Planet. On March 16, 1926, he successfully launched the world's first liquid propellant rocket. What followed was his development of basic rocket technology used by NASA for decades.

On May 6, 1992, replicas of Christopher Columbus' sailing ships Santa Maria, Nina, and Pinta sail by the Kennedy Space Center's Launch Pad 39B where Endeavour is awaiting liftoff on its maiden voyage, STS-49. Photo credit: NASA

Building on Goddard's research and that of those willing to explore over the next hill, NASA today is closing in on his dream of a trip to Mars.

Navigating the Seas

Throughout human history, the spread of civilization has been led by people who wanted to explore. Ancient voyagers included the Phoenicians, whose tin artifacts indicate they may have traveled as far as Britain. The Carthaginians explored the western coast of Africa. Greek travelers were the first to circumnavigate Britain and explore what is now Germany.

Among the greatest early explorers were Chinese mariners six centuries ago. A massive armada of nine-mast ships navigated west to Ceylon, Arabia and East Africa.

The leading Chinese pioneer was Zheng He who sailed using a magnetic compass invented in China centuries earlier. During his seven expeditions, he established a broad web of valuable trading routes from Taiwan to the Persian Gulf.

By the early 1500s, however, the Chinese navy was reduced to one-tenth of its size. As the policies of China's government turned inward, the navy was ordered to destroy the larger classes of ships, sending the nation into a centuries-long policy of isolation. Over time, the expertise to construct and navigate large ships was lost along with advances in technology.

In 1492, the European Age of Exploration began when the king and queen of Spain financed a voyage by Italian mariner Christopher Columbus. His expedition was to sail west from Europe seeking a more efficient route to India. His commitment to venture into the perils of the unknown has been shared by explorers throughout history.

"You can never cross the ocean unless you have the courage to lose sight of the shore," Columbus said.

His willingness to do so resulted in the discovery of a "new world."

This Age of Exploration has been hailed by many historians as one of the most important periods of geographical findings. From the 15th century until the 17th century, the voyages of explorers such as Ferdinand Magellan, Juan Ponce de León and James Cook resulted in the exploration and discovery of vast areas of North and South America, Africa, Asia and islands of the Pacific Ocean.

"I imagined how wonderful it would be to make some device which had even the possibility of ascending to Mars," thought 17-year-old Robert Goddard in 1899. In the Massachusetts snow on March 16, 1926, he took the first step by developing and launching the world's first liquid propellant rocket. Photo credit: NASA

Discovering New Lands

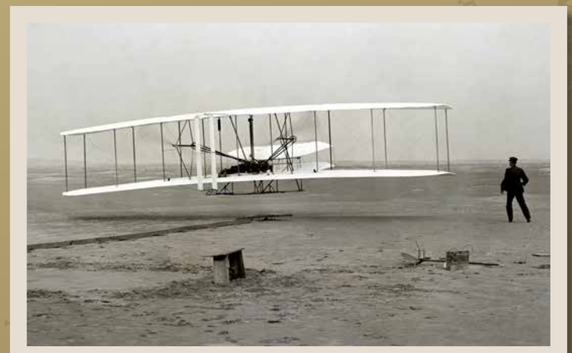
Among the early settlers to the "new world" of North America were the Pilgrims who established a colony in present-day Plymouth, Massachusetts. Following a treacherous 66-day voyage across the Atlantic Ocean aboard the Mayflower in 1620, the pioneers arrived to begin a new life.

William Bradford, who served as the Plymouth Colony's governor, echoed Columbus' statement.

"All great and honorable actions are accompanied with great difficulties, and both must be enterprised and overcome with answerable courage," he said.

Almost 200 years later, the United States had been established as a nation, but exploration continued. Those who traveled into what is now Ohio or Tennessee were considered as venturing into the "wild frontier."

Not long after the Louisiana Purchase of 1803, President Thomas Jefferson commissioned a select group of U.S. Army volunteers under the command of Capt. Meriwether Lewis and his close friend 2nd Lt. William Clark. Their expedition began in May 1804 and was the first to cross what is now the western portion of the nation. Beginning near St. Louis on the Mississippi River, they made their way westward through the continental divide to the



"The desire to fly is an idea handed down to us by our ancestors," said Orville Wright, seen here at the controls of the first successful powered flight. His brother, Wilbur, runs along at the side as the airplane traveled 120 feet in 12 seconds on Dec. 17, 1903, at Kitty Hawk, North Carolina. Photo credit: Library of Congress

"I believe the risks I take are justified by the sheer love of the life I lead," said Charles Lindbergh. The former U.S. Air Mail pilot became the first person to fly nonstop from New York to Paris in May 1927 aboard the aircraft he named the Spirit of St. Louis. Photo credit: Library of Congress

Chuck Yeager stands next to the rocket-powered X-1 aircraft. He broke the sound barrier on Oct. 14, 1947, flying the X-1 at Mach 1.06 (700 miles per hour or 1.06 times the speed of sound). He named the experimental plane Glamorous Glennis after his wife. Photo credit: U.S. Air Force

Pacific coast. Returning to their starting point in September 1806, Lewis and Clark established an American presence in previously unexplored territory.

Conquest of the Skies

By the turn of the 20th Century, most of the lands of the Earth had been explored and eyes began to turn to the skies.

"The desire to fly is an idea handed down to us by our ancestors who traveled across trackless lands in prehistoric times," said Orville Wright. "They looked enviously on the birds soaring freely through space, at full speed, above all obstacles on the infinite highway of the air."

Together with his brother, Wilbur, the bicycle builders from Dayton, Ohio, designed the world's first successful airplane. On Dec. 17, 1903, Orville made the first controlled, powered and sustained heavier-than-air flight at Kitty Hawk, North Carolina.

While the age of aviation had begun, initially some thought it would have its limitations.

"No flying machine will ever fly from New York to Paris," Orville Wright once said. "No known motor can run at the requisite speed for four days without stopping."

As aircraft became larger, more powerful and more efficient, a new age of exploration began and proved there were few limitations to the new technology.

One of those prepared to prove this notion was a former U.S. Air Mail pilot named Charles Lindbergh. On May 20 and 21, 1927, he flew a small, single engine aircraft from Roosevelt Field in New York to Le Bourget Airport in Paris.

A trait that continues to define explorers is a willingness to accept the inherent hazards.

"I believe the risks I take are justified by the sheer love of the life I lead," Lindbergh said.

The 1920s and 1930s were filled with news of aviation pioneers and explorers such as Richard Byrd, Amelia Earhart and Howard Hughes. During the World War II years, aircraft became larger, traveled farther, flew faster and climbed higher. Soon after, a new breed of explorer, known as test pilots "pushed the envelope" even farther –- again willing to accept the risks.

"You don't concentrate on risks," said U.S. Air Force pilot Chuck Yeager. "You concentrate on results. No risk is too great to prevent the necessary job from getting done."

On Oct. 14, 1947, Yeager flew the X-1 rocket plane faster than the speed of sound —- more than 700 mph — at Muroc Air Force Base, now Edwards Air Force Base, California. In doing so, he accomplished another feat once thought impossible.

President John Kennedy, right, and Dr. Wernher von Braun, director of the Marshall Space Flight Center, confer during a presidential visit to Redstone Arsenal, Alabama, in 1963. Both were committed to the boldest expedition of exploration to date – Apollo missions to the moon. Photo credit: NASA

Exploration of Space

By the late 1940s, a team of German-born rocket engineers and scientists were exploring beyond the skies into the edges of space, believing Goddard's dream of a trip to Mars was achievable.

"I have learned to use the word 'impossible' with the greatest caution," said Wernher von Braun who was leading what came to be known as the Rocket Team.

The history of exploration took the next logical step — venturing into outer space. The new explorers of the 20th century embraced the sentiment of Russian space pioneer Konstantin Tsiolkovsky.

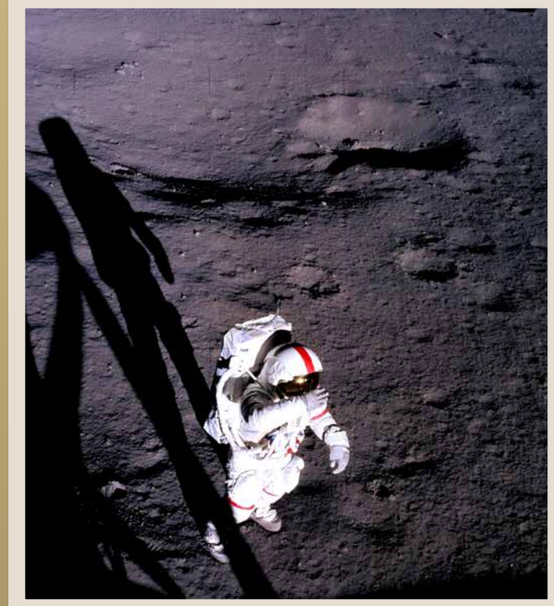
"The Earth is the cradle of humanity," he said, "but one cannot live in a cradle forever."

On Oct. 3, 1957, scientists and engineers in the Soviet Union were the first to take a small step out of the "cradle" when they launched the world's first satellite, Sputnik 1.

The United States orbited its first satellite, on Jan. 31, 1958. It was appropriately named "Explorer 1." It was launched from Cape Canaveral Air Force Station in Florida using a Redstone rocket developed by von Braun's team.

A few weeks later, von Braun was interviewed by Time magazine about the possibility of humans traveling into space.

On July 20, 1969, exploration reached another world as U.S. astronauts Neil Armstrong and Buzz Aldrin landed on the moon. With the Apollo 11 lunar module, Eagle, in the background, Aldrin sets up the Early Apollo Scientific Experiments Package. Photo credit: NASA/Neil Armstrong



America's first person in space, Alan Shepard, made his second trip beyond Earth commanding Apollo 14. Photographed from a window in the lunar module, he holds his right glove over his helmet visor as if to shade his eyes from the brilliant sun as he surveyed the moon's Fra Mauro region. Shepard and Edgar Mitchell landed Feb. 5, 1971, exploring the moon during two moonwalks. Photo credit: NASA/Edgar Mitchell

"It was just a few short years ago that President Obama himself stood here in the (Kennedy Space Center's) Armstrong Operations and Checkout building and committed us to a journey to Mars," said NASA Administrator Charlie Bolden on Feb. 2, 2015. Seated to Bolden's left is Kennedy's director, Bob Cabana. On display in the background, from the left, are Boeing's CST-100, NASA's Orion and the SpaceX Dragon spacecraft. All are designed to play a role in the agency's exploration objectives. Photo credit: NASA/Amber Watson

This artist concept depicts NASA's Space Launch System (SLS) rocket as it would appear on its launch pad during preparations for liftoff. The SLS is now being built along with the Orion spacecraft to send astronauts to Mars, achieving Robert Goddard's dream of a "device" to ascend to the Red Planet. Photo credit: NASA/Marshall Space Flight Center

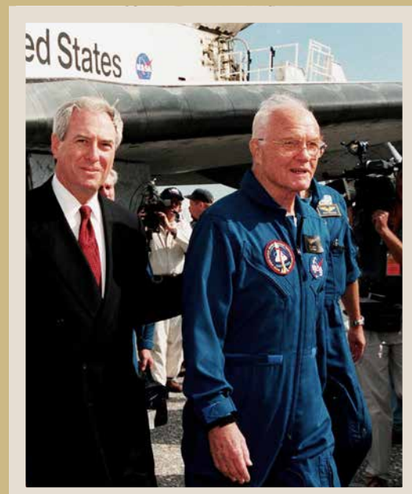
"Don't tell me that man doesn't belong out there," he said. "Man belongs wherever he wants to go and he'll do plenty well when he gets there."

A Soviet was the first to get there in the spring of 1961.

Visionaries such as Robert Gilruth, who headed NASA's Space Task Group at the Langley Research Center in Virginia, saw the achievement coming.

"I can recall watching the sunlight reflect off of Sputnik as it passed over my home on the Chesapeake Bay in Virginia," he said. "It put a new sense of value and urgency on things we had been doing. I was sure that the Russians were planning for man in space."

Cosmonaut Yuri Gagarin became that first person to travel in orbit on April 12, 1961.



"Every time America has gone to the frontier, we've brought back more than we could ever imagine," said former NASA Administrator Dan Goldin, on the left. He is seen walking with Sen. John Glenn (D-Ohio) on Nov. 7, 1998. Glenn had just returned to Earth following the STS-95 space shuttle mission. Glenn's initial trip into space on Feb. 20, 1962, aboard Mercury 6 made him the first American in orbit. Photo credit: NASA

A few weeks later, American astronaut Alan Shepard blasted into space atop one of von Braun's Redstone rockets. He flew aboard a Mercury spacecraft designed by Gilruth's team at Langley.

With humans showing they could "do plenty well" in space, President John Kennedy asked Americans to join in the boldest mission of exploration to date — "landing a man on the moon and returning him safety to Earth."

Kennedy spoke eloquently about space as an unexplored ocean to be navigated.

"We set sail on this new sea because there is new knowledge to be gained, and new rights to be won, and they must be won and used for the progress of all people," he said on Sept. 12, 1962, in a speech at Rice University in Houston. "But why, some say, the moon? Why choose this as our goal?"

In answering his own hypothetical question, Kennedy explained why we explore.

"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," he said, "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."

That goal was achieved on July 20, 1969, when Apollo 11 astronauts Neil Armstrong and Buzz Aldrin landed on the moon's Sea of Tranquility. Through December 1972, five more Apollo crews landed on the lunar surface, exploring and returning to Earth.

In 1992, then NASA Administrator Dan Goldin noted that the point of exploration isn't just the destination, it's the journey.

"It's not about going someplace, it's about what you find along the way," he said. "Walk into any hospital and look at the technology. CAT scans, magnetic resonance, intensive care monitoring equipment — all derivatives of Apollo. No wonder Newsweek called Apollo 'the best return on investment since Leonardo da Vinci bought himself a sketch pad.'"

During three decades, NASA's Space Shuttle Program flew 135 missions to not only utilize the benefits of microgravity in Earth orbit, but to learn how to live and work in space. The continuing legacy of the shuttle is the International Space Station where astronauts from around the world are learning what we need to know for the next giant leap — an expedition to the Red Planet.

As President Barak Obama spoke on space exploration in the 21st century in an address at Kennedy Space Center on April 15, 2010, he called for another exploration challenge. This time, the mission is to embark on a 58-million-mile trip almost losing site of the shores of Earth.

"By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth," he said. "And a landing on Mars will follow."

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

At the Humans to Mars Summit on May 5, 2015, NASA Administrator Charlie Bolden explained America's reasons for the journey. He noted that by looking back, we look forward.

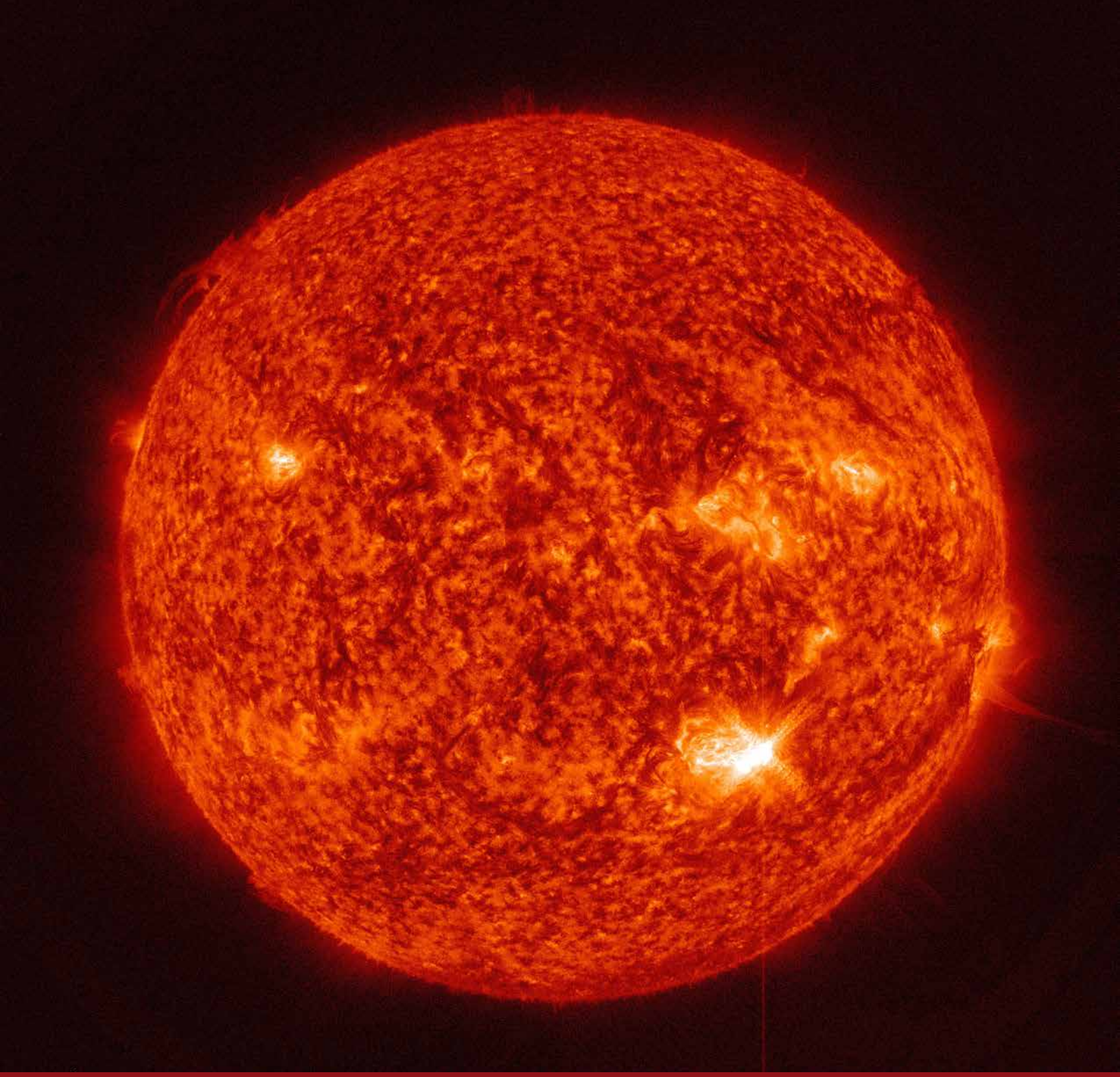
In this artist's rendering, a Space Launch System rocket lifts off with an Orion spacecraft atop. NASA's heavy-lift launch vehicle will provide a new capability for human exploration beyond low-Earth orbit to destinations such as Mars. Image credit: NASA

This artist's rendering represents a concept of possible activities during future space exploration missions to Mars. Image Credit: NASA

"Because what we learn about the Red Planet may tell us more about our own home planet's history and future," he said, "and because it might just help us unravel the age-old mystery about whether life exists beyond Earth ... Mars matters."

The primary objective is the one envisioned by Robert Goddard as he looked into the sky during his youth and envisioned a trip to Mars. As Goldin noted, the journey will be worth the effort.

"Every time America has gone to the frontier, we've brought back more than we could ever imagine," he said. "As NASA turns dreams into realities, and makes science fiction into fact, it gives America reason to hope our future will be forever brighter than our past."



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