ROCKET STEM

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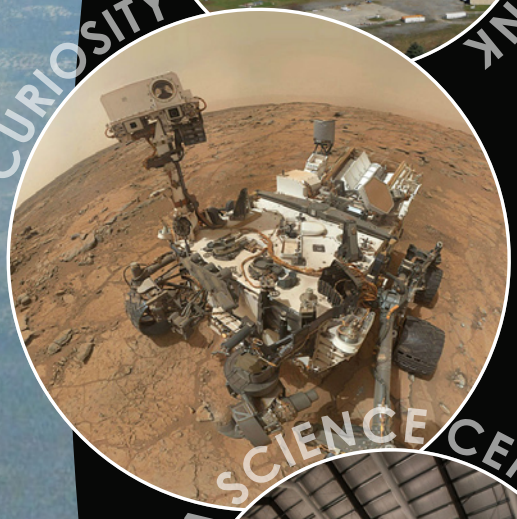
APRIL 2013

Photo: Julian Leek

SKYLAB

GREEN BANK



CURIOSITY

CALIFORNIA SCIENCE CENTER

Exploring Space
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+ Engineering
+ Mathematics
Plus **YOU!**

Welcome to the second issue of RocketSTEM magazine. In this spring edition, we take you:

- Inside the life and research of an astronomer at the Green Bank Telescope.
- To the top of NASA's VAB for a view of a SpaceX launch.
- A first-hand account of being aboard America's first space station, Skylab.
- Riding along in a Pave Hawk with the Air Force's 920th Rescue Wing.
- And much, much more.

We welcome your comments and suggestions for how to improve the magazine, and are always open to adding new contributors for future issues.

Please feel free to contact us via email at **ideas@rocketstem.org** with your feedback or story ideas.

RocketSTEM is a non-profit media foundation devoted to promoting STEM education and space exploration. Our mission is to:

- Inspire the next generation of scientists, engineers and astronauts.
- Keep educators informed on space developments while helping them better incorporate STEM lessons into their classrooms.
- Raise awareness of the benefits of space exploration.

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

An Atlas V rocket, carrying the SBIRS GEO-2 satellite, blasts off from LC-41 on March 19.

Photo: Sherry Valare

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This is the second issue of RocketSTEM magazine, which will be published monthly beginning in August. The third issue will be released in mid to late June of this year.

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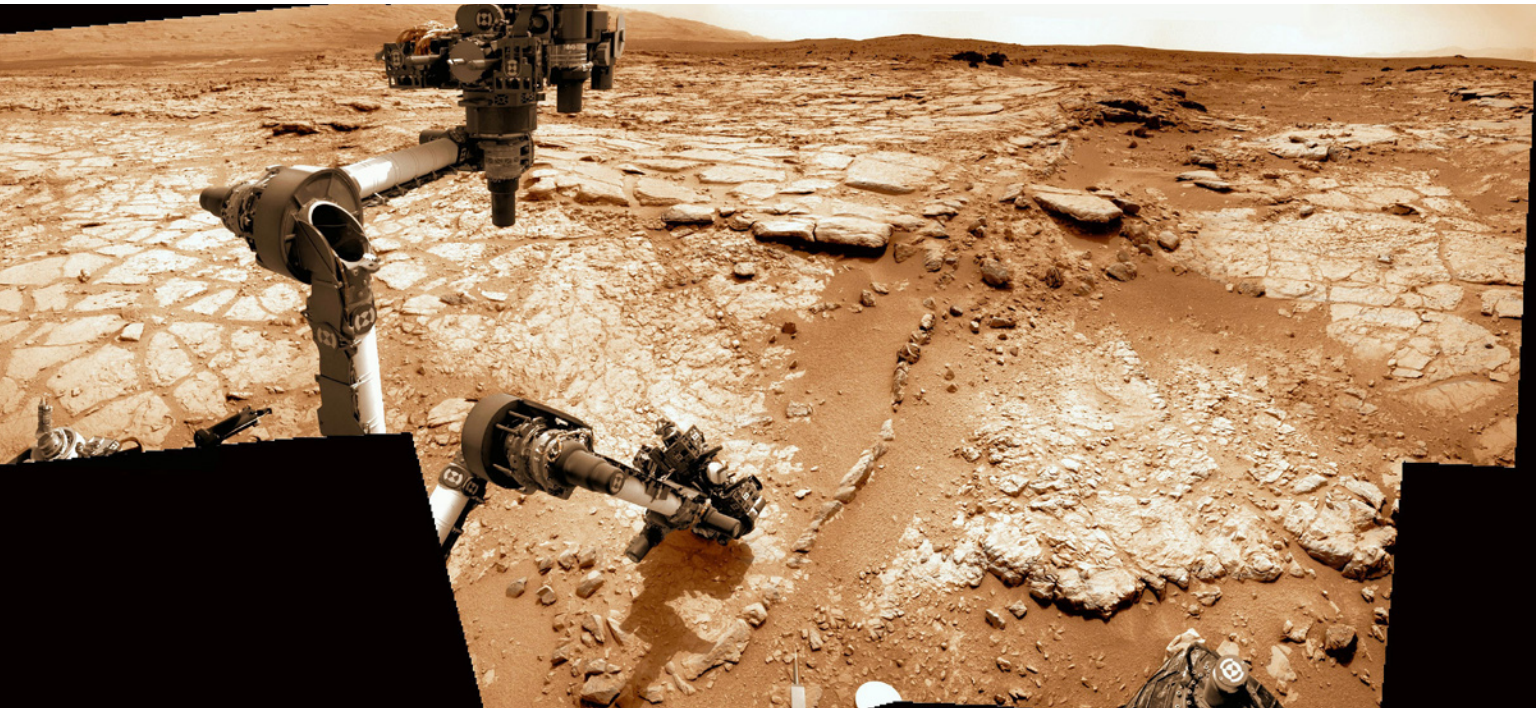


This mosaic shows Curiosity rover's arm on Sol 149 (Jan. 5, 2013) at Yellowknife Bay basin where the rover has found widespread evidence for flowing water and discovered hydrated mineral veins and concretions around the rock ledge ahead and by the slithery chain of narrow protruding rocks known as Snake River. *Photo: NASA/JPL-Caltech/Ken Kremer/Marco Di Lorenzo*

MISSION ACCOMPLISHED!

Curiosity discovers a habitable environment for life on Mars

By Ken Kremer

As NASA's Curiosity rover begins her eighth month exploring the Red Planet since the nail-biting touchdown inside Gale Crater on Aug. 5, 2012, she has made the most amazing finding thus far.

After analyzing the first powder ever drilled from the interior of a Martian rock, Curiosity discovered key chemical ingredients necessary for life to have thrived on early Mars billions of years ago.

Collecting those first particles bored from inside a rock on a planet beyond Earth marks a historic feat in humankind's exploration of the cosmos - and was crucial for achieving Curiosity's goal to determine whether Mars ever could have supported microbial life, past or present.

Curiosity has now achieved her goal of discovering a habitable environment on the Red Planet, mission scientists reported at a mid March briefing held at NASA headquarters in Washington, D.C.

Data collected by Curiosity's two analytical chemistry labs (SAM and CheMin) confirm that the gray powder collected from inside the sedimentary rock of mudstone where the rover is now exploring - near an ancient Martian stream bed - possesses a significant amount of phyllosilicate clay minerals; indicating an environment where Martian microbes could once have thrived in the distant past.

Clay minerals form in neutral water which is much more conducive to supporting possible Martian life forms compared to the highly acidic watery environments found by NASA's Spirit and Opportunity Mars rovers over the past decade.

"We have found a habitable environment which is so benign and supportive of life that probably if this water was around, and you had been on the planet, you would have been able to drink it," said John Grotzinger, the chief scientist for the Curiosity Mars Science Laboratory mission at the California Institute of Technology in Pasadena, Calif.

Curiosity cored the rocky sample from a fine-grained, sedimentary outcrop, named John Klein, inside

a shallow basin named Yellowknife Bay, and delivered pulverized powder to the Sample Analysis at Mars (SAM) and Chemistry and Mineralogy (CheMin) instruments inside the robot.

On Feb. 8, 2013 (mission Sol 182), Curiosity used the rotary-percussion drill mounted on the tool turret at the end of the seven-foot (2.1 meter) long robotic arm to bore a circular hole about 0.63 inch (16 mm) wide and about 2.5 inches (64 mm) deep into John Klein that produced a slurry of gray tailings.

"For the first time we are examining ancient rocks that have not been exposed to the Martian surface environment, and weathering, and preserve the environment in which they formed," said Joel Hurowitz, Curiosity sampling system scientist at JPL.

This is a key point because subsequent oxidation reactions can destroy organic molecules and thereby potential signs of habitability and life.

The gray colored tailings give a completely fresh insight into Mars that offers a stark contrast to the prevailing views of reddish-orange rusty, oxidized dust. One theory is that it might be related to different oxidations states of iron that could potentially inform us about the habitability of Mars inside the rover's Gale Crater landing site.

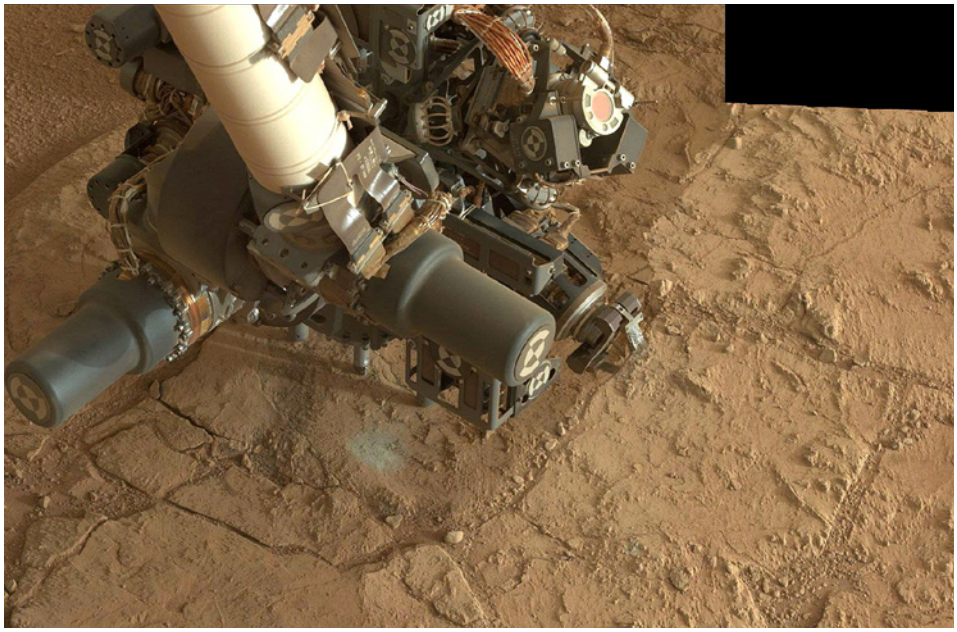
The presence of abundant phyllosilicate clay minerals in the John Klein drill powder indicates a fresh water environment. Further evidence derives from the veiny sedimentary bedrock shot through with calcium sulfate mineral veins that form in a neutral to mildly alkaline pH environment.

"Clay minerals make up at least 20 percent of the composition of this sample," said David Blake, principal investigator for the CheMin instrument at NASA's Ames Research Center in Moffett Field, Calif.

The rovers long robotic arm fed aspirin-sized samples of the gray, pulverized powder into the miniaturized CheMin SAM analytical instruments on Feb. 22 and 23, or Sols 195 and 196. The samples were analyzed on Sol 200.

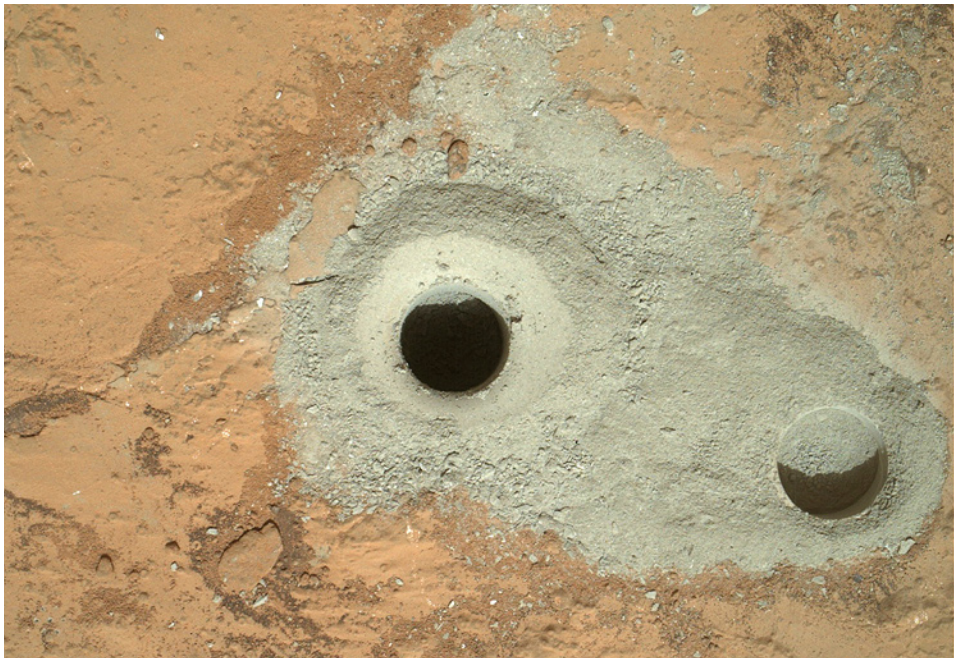
Scientists were able to identify carbon, hydrogen, oxygen, nitrogen, sulfur and phosphorus in the sample - all of which are essential elements for life as we know it based on organic molecules. But no significant levels of organics have been detected yet.

"The range of chemical ingredients we have identified in the sample is impressive, and it suggests pairings such as sulfates and sulfides that indicate a possible chemical energy source for micro-

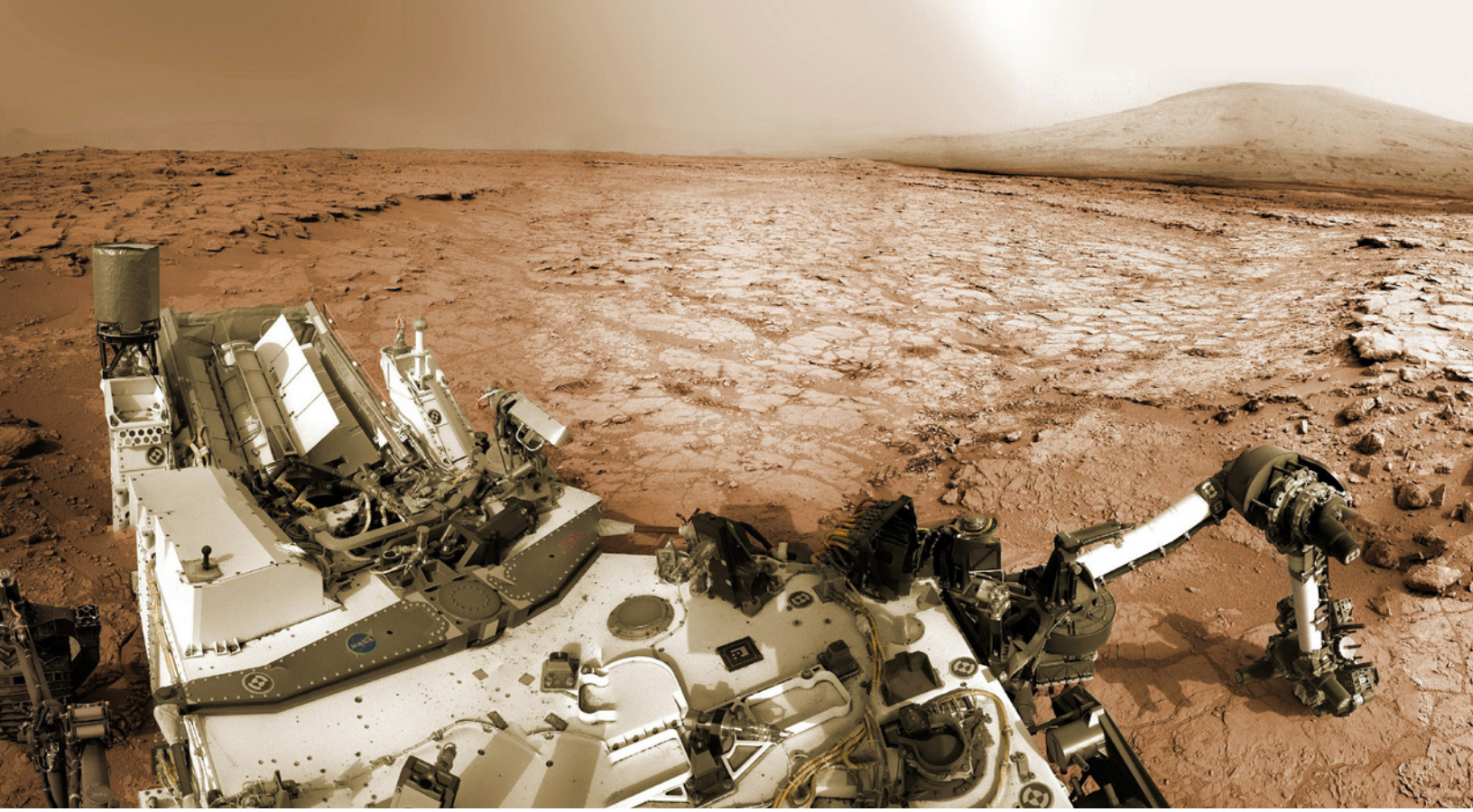


Curiosity tool turret located at end of robotic arm is positioned with drill bit in contact with John Klein outcrop for first hammer drilling into Martian rock surface on Jan 31, 2013.

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



At the center of this image is the hole in a rock where the Curiosity rover conducted its first sample drilling on Mars during its 182nd Martian day of operations. A test that produced the shallower hole two days earlier is shown to the right. The sample-collection hole is 0.63 inch (1.6 centimeters) in diameter and 2.5 inches (6.4 centimeters) deep. The "mini drill" test hole has a depth of 0.8 inch (2 centimeters). *Photo: NASA/JPL-Caltech/MSSS*



Curiosity is shown in this context mosaic view of the Yellowknife Bay basin taken on Jan. 26 (Sol 169) where the robot is currently working. The robotic arm is pressing down on the surface at John Klein outcrop of veined hydrated minerals – dramatically backdropped with her ultimate destination; Mount Sharp.

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

organisms," said Paul Mahaffy, principal investigator of the SAM suite of instruments at NASA's Goddard Space Flight Center in Greenbelt, Md.

"The rock drilling capability is a significant advancement. It allows us to go beyond the surface layer of the rock, unlocking a time capsule of evidence about the state of Mars going back three or four billion years," said Louise Jandura of JPL and Curiosity's chief engineer for the sampling system. "Using our roving geologist, Curiosity, the scientists can choose the rock, get inside the rock and deliver the powdered sample to instruments on the rover for analysis."

The high powered drill was the last of Curiosity's 10 state-of-the-art instruments still to be checked out and put into full operation.

The discovery of phyllosilicates on the floor of Gale crater was unexpected, and has delighted the scientists. Based on spectral observations from Mars orbit. Grotzinger told me previously that phyllosilicates had only been detected in the lower reaches of Mount Sharp, the three mile (5 km) high mountain that is Curiosity's ultimate destination.

Finding the phyllosilicates so soon at Yellowknife Bay is a tribute to the team and validates the selection of Gale Crater as the landing site.

Grotzinger said that Curiosity

The little rover that could

Opportunity still making discoveries

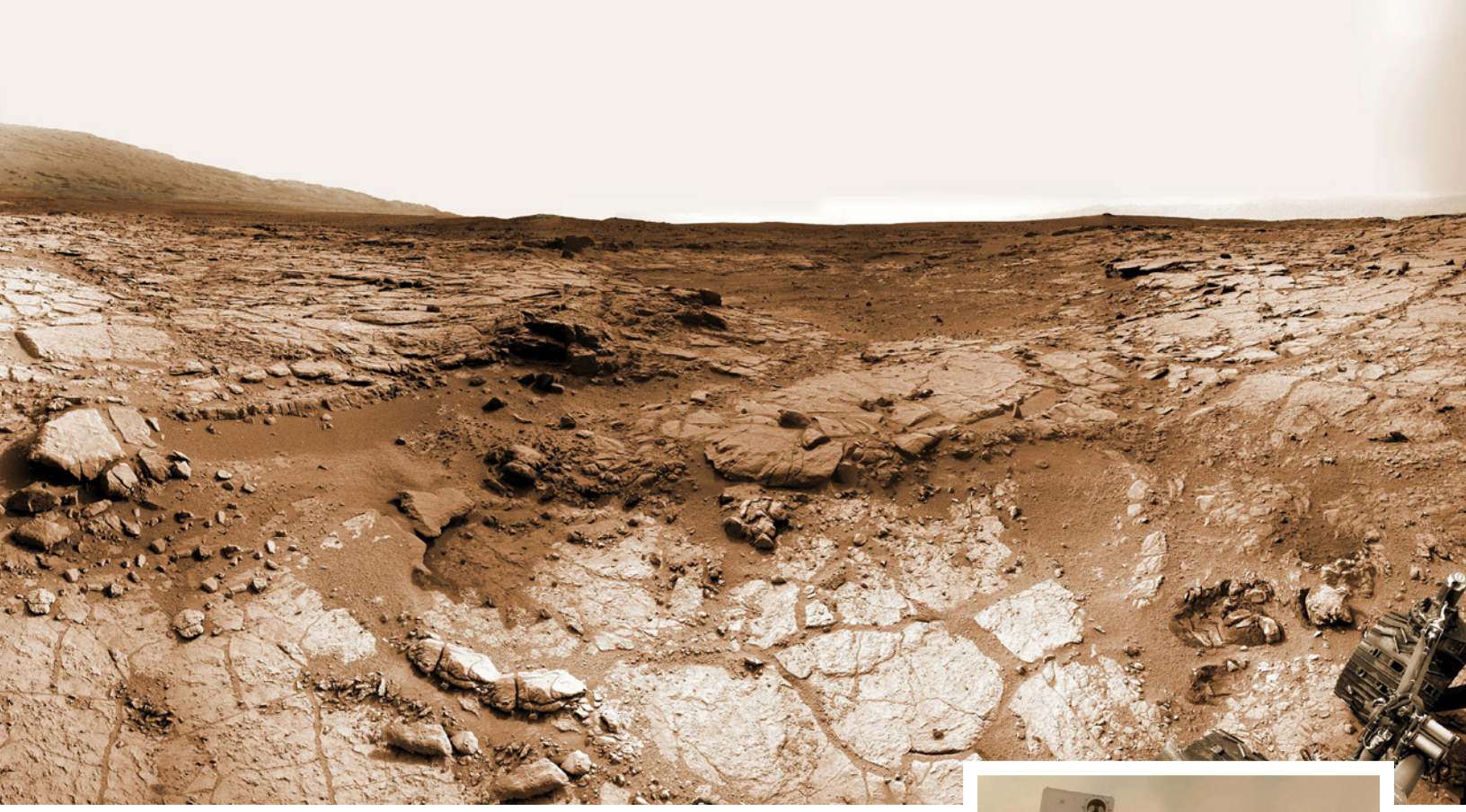
By Ken Kremer

Nine years ago, NASA's pair of identical twin Martian sisters - Spirit & Opportunity - bounced to daunting airbag-cushioned landings on opposite sides of the Red Planet for what was supposed to be merely 90 day missions.

Today, Opportunity celebrates a truly unfathomable achievement, entering Year 10 on Mars since she rolled to a bumpy stop on January 24, 2004. Now she's at a super sweet spot for science loaded with clays and veined minerals and making the most remarkable findings yet about the planets watery past - building upon a long string of unthinkable discoveries due to her totally unforeseen longevity.

"Regarding achieving nine years, I never thought we'd achieve nine months!" said Principal Investigator Prof. Steve Squyres of Cornell University. "Every sol is a gift for our priceless assets on Mars."

As of April 1, Opportunity has exceeded 3200 Sols, or Martian days. She is now 111 months into the three-month primary mission - that's 37 times longer than the 90 day "warranty." The rover remains healthy, has snapped over 178,000 images and driven over 22 miles - marking the first overland expedition on another planet.



Curiosity snapped this self portrait (right) on Feb. 8 with the MAHLI camera while sitting on flat sedimentary rocks of mudstone at the John Klein outcrop.

Photo: NASA/JPL–Caltech/MSSS/Ken Kremer/Marco Di Lorenzo

will remain in the Yellowknife Bay area for several additional weeks or months to fully characterize the area. The rover will also conduct at least one more drilling campaign to try and replicate the results, check for organic molecules and search for new discoveries.

The Curiosity science team believes that the current work area at Yellowknife Bay experienced repeated percolation of flowing liquid water billions of years ago when Mars was warmer and wetter - and therefore was more hospitable to the possible evolution of life.

So far Curiosity has snapped more than 48,000 images, traveled nearly 0.5 miles, conducted 25 analysis with the APXS spectrometer and fired over 12,000 laser shoots with the ChemCam instrument.

Eventually, the six-wheeled mega rover will set off on the nearly year long trek to the base of Mount Sharp.

The resilient, solar powered Opportunity robot is roving around Martian terrain where she proved that potentially life sustaining liquid water once flowed billions of years ago when the planet was warmer.

She is investigating the inboard edge of Cape York - a hilly segment of the eroded rim of 14 mile (22 km) wide Endeavour Crater, featuring terrain with older rocks than previously inspected and unlike anything studied before. It's a place more than three billion years old that no one ever dared dream of reaching prior to launch in the summer of 2003.

Opportunity has accomplished breakthrough science by finding deposits of phyllosilicates - clay minerals stemming from an earlier epoch when liquid water flowed on Mars eons ago and perhaps may have been more favorable to sustaining microbial life because they form in more neutral pH water. They have never before been analyzed up close on the Martian surface; and have also just been discovered by NASA's new Curiosity rover at Gale Crater.

"We have found phyllosilicates at the Whitewater Lake area around Cape York, said Squyres. "It's like a whole new mission since we arrived at Cape York." Opportunity also discovered additional hydrated mineral veins at Whitewater Lake, in addition to those found earlier at a spot named Homestake.

Opportunity will continue to explore around the crater rim.

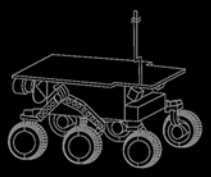
MARS ROVER CC

NO. OF WHEELS

LAUNCH DATE

1990

SIZE OF LANDING ELLIPSE



Sojourner

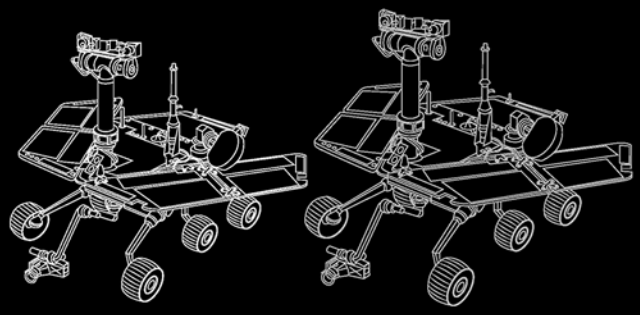
Mission Objective: Demonstrate a low-cost way of delivering a set of science instruments and a rover to Mars and return geological, soil, magnetic property and atmospheric data.

Easter Island

12 miles

December 4, 1996

approx. 50 miles



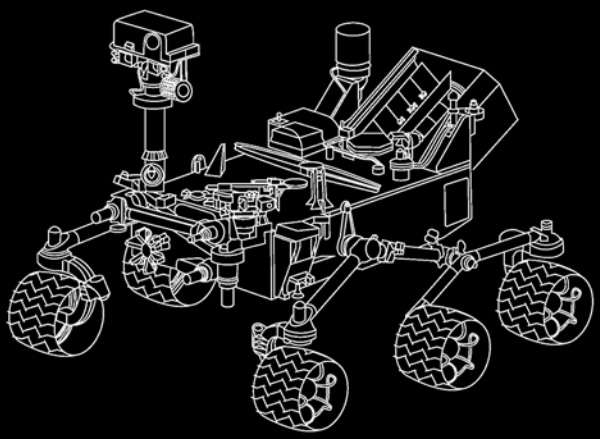
June 10, 2003

Spirit & Opportunity

Mission Objective: Search for and characterize a wide range of rocks and soils that hold clues to past water on Mars.

July 7, 2003

approx. 125 miles



6 wheels

November 26, 2011

Curiosity

Mission Objective: Assess whether the Martian landing area has ever had or still has environmental conditions favorable to microbial life -- in terms of both habitability and preservation.

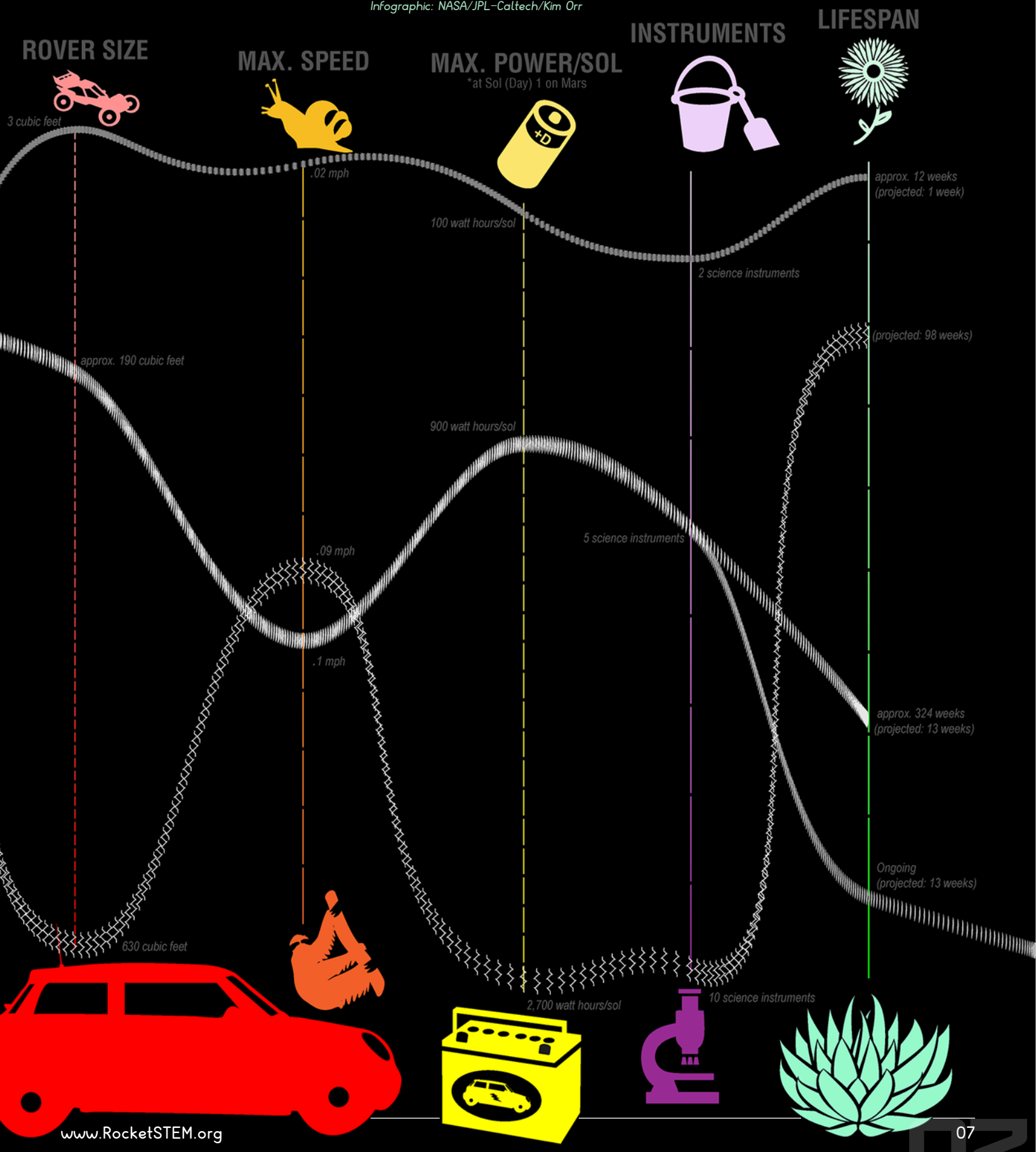
Iceland

2020

(comparison chart)

Starting with the Sojourner rover, launched in 1996, NASA has sent four robotic rovers to the Red Planet. On November 26, 2011, NASA launched Curiosity, its most technologically advanced rover ever. At a glance, it's easy to see the size evolution between NASA's youngest and oldest rover, but how else have they evolved? This chart uses common terrestrial concepts to explore the evolution of NASA's four other-wordly machines.

Infographic: NASA/JPL-Caltech/Kim Orr



Former astronaut Leland Melvin, NASA's associate administrator for education, speaks about the Exploration Design Challenge as Orion manager Mark Geyer, NASA Administrator Charles Bolden and Lockheed Martin CEO Marillyn Hewson look on.

Photo: Robert Pearlman/collectSPACE.com

Contest challenges students to design new radiation shield

NASA is challenging school-children to protect their future ride into space. The agency's Exploration Design Challenge (EDC), announced March 11 during an event at the Johnson Space Center in Houston, engages U.S. students in kindergarten through high school in helping to solve the known problem of increased radiation exposure encountered on flights into deep space.

"If not all of us, most of us remember the immortal words associated with the 1970 Apollo 13 mission, 'Houston, we have a problem,'" said NASA Administrator Charles Bolden while standing before a mockup of the agency's new Orion crew capsule. "Today, we are here to announce an effort in partnership with Lockheed Martin and the young people of America that will allow us to take about a year from now to proclaim, 'Houston, we have a solution.'"

Through teacher-led classroom activities and, for the older entrants, access to the resources to design, and perhaps build and then fly into space a prototype radiation shield, students from across the nation will be able to contribute to the first flight of the Orion multi-purpose crew vehicle (MPCV), the Exploration Flight Test (EFT-1), targeted for launch in September 2014.

"When Orion takes its first flight in 2014, that's next year, it'll travel farther into space than any spacecraft developed for human spaceflight in the 40 years since our astronauts returned from the moon," Bolden said. "This will require new technologies, including new ways to keep astronauts safe from deep space radiation. That is the purpose of this challenge and we're excited that American students will be helping us solve that problem."

Authored by Robert Pearlman, this article appeared first at collectSPACE.com.

Banking on student designs

The EFT-1 mission will launch from Cape Canaveral, Fla., on a United Launch Alliance Delta IV Heavy rocket, which will boost an unmanned Orion capsule on a two-orbit flight around the Earth. Once in space, the craft will rise to more than 3,600 miles (5,800 kilometers) above the planet — 15 times higher than the International Space Station — prior to turning around to come home to perform a high-energy test of its heat shield.

The elliptical orbit that the Orion will follow will result in the craft lingering in the Van Allen radiation belts surrounding the Earth. This trajectory will expose the vehicle to much higher levels of radiation than a typical low Earth orbit or even moon-bound mission would encounter.

The EFT-1 Orion will be equipped with a NASA-designed radiation sensor to measure the harsh space environment that the capsule will fly through. But it may be the student design for a radiation shield that offers the breakthrough technology for astronauts to follow on future missions.

"My guess is that we will see something we never

thought about," Bolden stated in an interview, referring to the outcome of the EDC. "It may be totally different and it may even be affordable, which is most important. So, it is my expectation that we will find something that we didn't think about."

The design challenge is divided into three levels. For the first two groups – children in kindergarten through 4th grade, and 5th through 8th grades – their teachers will lead them through studying the effects of radiation on human space travelers and analyzing materials that can simulate space radiation shielding for Orion. After participating in these activities, the students will recommend materials that best block harmful radiation.

At the high school level, grades 9 through 12, students will design the shielding to protect a sensor inside Orion from space radiation.

"There will be five teams chosen to test their designs in a virtual radiation simulator," said Leland Melvin, a Space Shuttle astronaut and NASA's associate administrator for education. "All five teams that are chosen will go down to Kennedy Space Center for the launch of EFT-1 and there will be a final down-select of the winning design that will possibly be flown on EFT-1."

"We're banking on this design because one of you, or one of our astronauts, will be flying to Mars," he said. "We will be using space-certified radiation sensors sitting behind your radiation shield to see how effective it is working at blocking radiation."

An artist concept (above) shows Orion as it will appear in space for the Exploration Flight Test–1 attached to a Delta IV stage. (Left) NASA's Orion Exploration Flight Test–1 (EFT–1) insignia. *Images: NASA*

Laying the foundation

"All of you who participate will be part of something that has never been done before, the first test flight of Orion," Marilyn Hewson, president and CEO of Lockheed Martin, said, addressing the students who attended the event and who were watching live on NASA's television channel.

Lockheed Martin is NASA's prime contractor for the Orion MPCV and is building the capsule that will fly on EFT-1.

"Every journey starts with a single step and the Orion's Exploration Flight Test-1 is a significant first step toward deep space human exploration," she said. "This mission will lay the foundation for future Orion flights and will take astronauts past the moon and on to asteroids and Mars."

All the students who take part in the design challenge will join the mission as "honorary crew members" by having their names flown aboard the Orion.

The winning team's status will be more than honorary — their radiation shield design may someday protect Orion's real crew members.

"You're about to embark on an amazing journey," Hewson said. "The skills you'll learn from this challenge — problem solving, critical thinking and systems engineering — are the very same skills that our engineers apply to our most challenging problems every day."

"You are taking on a mission that is hugely important — keeping our astronauts safe during a journey through deep space."

For details on how students can enter NASA's Exploration Design Challenge, see NASA's Education website.

NASA Administrator Charles Bolden and Lockheed Martin CEO Marillyn Hewson sign an agreement enabling NASA's Exploration Design Challenge for students.

Photo: Robert Pearlman/collectSPACE.com

Stargazing to discover secrets of the Milky Way

Green Bank offers unique view to Dr. Lockman

Interview by Chase Clark

Dr. Felix James (Jay) Lockman has spent the past two decades probing the origin of the Milky Way. He conducts his research from a rural area in West Virginia, a special place for radio astronomy that is unmatched anywhere else in the United States, using the Green Bank Telescope of the National Radio Astronomy Observatory.

Q: The Green Bank Telescope is at an observatory in West Virginia that is unlike most other observatories in the world. Why is that?

Lockman: "Green Bank is unique. It is a radio astronomy observatory, so instead of being on a mountain peak, it's in a valley that's surrounded by the Appalachian Mountains and national forests. The mountains protect us from man-made radio waves that would interfere with the very faint radio signals coming from the universe. Just as optical observatories have to be concerned with light polution, we need to be in a fairly isolated place with good shielding from radio wave interference.

"We have not only our mountains for shielding, but also the National Radio Quiet Zone. When the Observatory was established more than 50 years ago, the National Radio Quiet Zone was created around it, within which new transmitters are controlled so that they don't interfere with the radio telescopes. This is a unique region in the United States. We don't have cell phone reception in the valley and we don't have wireless at the Observatory. People one valley over can have it, but as you get closer and closer to the Observatory, the restrictions start to kick in. It makes Green Bank unusual, but a very good place to do radio astronomy.

Astronomer Dr. Jay Lockman

"Being in such a rural area has its advantages and disadvantages. I guess the biggest disadvantage – unless you think of the absence of cell phones as a disadvantage – the biggest disadvantage is that you need to drive some distance to do routine shopping.

"It's rural America. Green Bank has the amazing juxtaposition of a facility with the absolute start-of-the-art, unique scientific instrumentation, in a very rural part of the East."

Q: Is it true that common household items can interfere with the telescope?

Lockman: "Yes, it's a funny thing. There are the intentional transmitters such as cell phone towers, TV stations and so on. But then there are things that unintentionally give off radio waves. Digital cameras for example. Sometimes an ordinary device begins to give off radio waves when it starts to malfunction, or behave abormally.

"When we detect these interfering signals, if it appears to us that they are coming from some local source, we have a van with antennas bristling out the top that can track them down. One very amusing example occured a few years back. It was a heating pad in a doghouse. The wet dog would come in and lie down on this heating pad that wasn't designed to have a wet dog on it, and the thing would start to short out internally. The short was giving off bursts of radio waves that we were picking up. We replaced the dog pad with a new one that was waterproof, at no charge to the owner. That eliminated the interference, and probably saved the dog's life at the same time."

Q: The stereotypical view of an astronomer is a person who spends all night staring through a giant telescope at the stars. Is that a fair assessment?

Lockman: "No. In fact, because I study the radio waves that come in from space, I can use the radio telescope any time of the day or night. The daytime radio sky is dark, not bright blue like the daytime sky at visible wavelengths. When I'm on a project I might be scheduled from midnight to 2 a.m. or from 8 a.m. to midnight. You really can't tell. It makes for a very different kind of cycle to your day.

"Most of the time, I am not using the telescope. The typical research

projects I do use a telescope for just a few tens of hours, but then there's many months of trying to understand what it is exactly that we found."

Q: With such a vast universe, do astronomers simply focus on a single question, or are they multitaskers, seeking the answers to multiple questions at once?

Lockman: "Individual astronomers tend to do research in just one or two areas. I typically have several projects going at once, sometimes lasting several years. Between the time that you devise an experiment, and the time that you actualy get to use a telescope may be a year or more. So I'm really doing multiple projects and I have collaborators scattered around the world that are in complementary fields to radio astronomy."

"One thing I'm very interested in is the extent of the Milky Way. How far out does it really go? And what is happening at the transition between galactic and intergalactic space? We can study that using radio waves. We can study that in the ultraviolet using data from the Hubble Space Telescope. We can study that in the infrared using data from other telescopes.

"If you go out on a clear night what you will see is stars in the Milky Way, our home galaxy. Stars like the Sun put out most of their energy at optical, visible, wavelengths. They shine in the visible and we can see that.

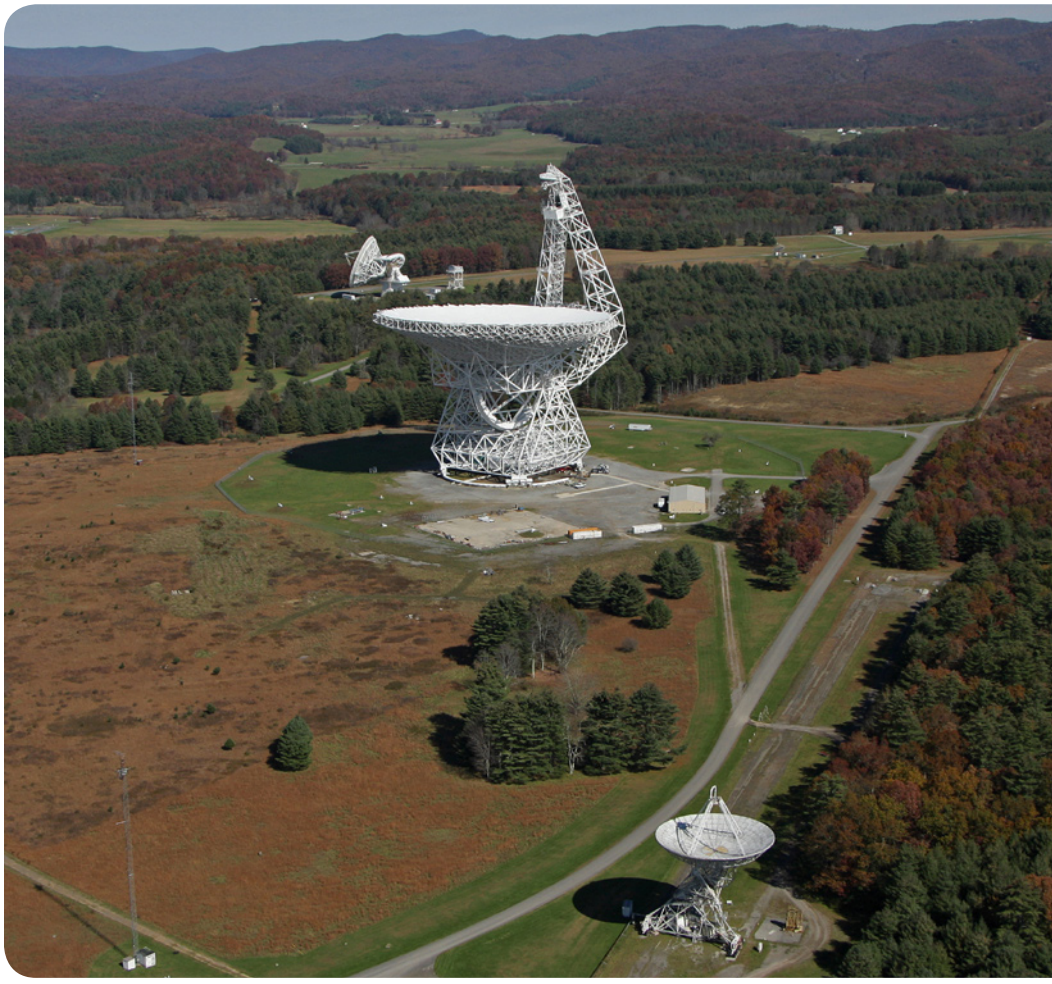
"In-between the stars, though, there are clouds of dust and gas that do not give off visible light, but shine very brightly in radio waves. And they can shine very brightly at infrared wavelengths as well. So the universe that we study with radio waves, is very complementary to the universe that we can study with visible light.

"You need all of this to put together a coherent picture of what's going on. There are many things out there that don't give off any visible light at all."

Q: Does working on a radio telescope require a different skillset than an optical telescope?

Lockman: "You need a broad background in the physical sciences and mathematics, and above all an interest in doing astronomical research. Anyone who is smart enough and has the diligence to become a sucessful research scientist could certainly succeed in many other fields. But there is something very special about being at the edge of discovery, and about being the first person to learn something new about our Universe. That ability to discover something new appeals to me.

"The educational background needed to be an astronomer or astrophysicist is about the same regardless of what instruments you end up using. You do need to learn a number of very specific instrumental techniques, or if you are making theoretical calculations on a computer, you would need to learn some specialized numerical techniques."



The Robert C. Byrd Green Bank Telescope, located in West Virginia, is the one of the world's premier single-dish radio telescopes. With access to 85 percent of the celestial sphere, the telescope is in operation an average of nearly 18 hours per day. *Photo: Walter Scriptunas II*

Q: Do we need both Earth-based and space-based telescopes?

Lockman: "It's a great question. As we sit here on the surface of the Earth, we're protected by the atmosphere from a lot of really nasty radiation that the sun gives off. We're protected from most of the ultraviolet radiation and the X-rays and the high-energy particles. But conversely, if we want to study

X-rays from the Sun, for example, we've got to get up above the atmosphere and go into space.

"There are two wavelength bands where the atmosphere is transparent and lets in radiation from outside. One is at visible wavelengths. After all you can see the stars at night and that means that the sky is transparent to visible light. The other is in the radio. The long wavelengths of radio waves, the low energy photons, come pretty much unimpeded through the atmosphere. Only at visible and radio wavelengths can astronomy be done from the ground. If you want to study ultraviolet, or most infrared emission, or X-rays, you've got to go into space. So again, it's complementary."

The Green Bank Telescope is the world's largest fully steerable radio telescope. Sitting within the heart of the National Radio Quiet Zone. The telescope focuses 2.3 acres of radio light on sensitive receivers at the top of the telescope. It is 485 feet tall which is nearly as tall as the nearby mountains. *Photo: Walter Scriptunas II*

Q: How did you become an astronomer and end up working with the NRAO?

Lockman: "I was always interested in science. Luckily, I got to attend Drexel University in Philadelphia. It has a cooperative education program that puts students to work in industries related to their major field of study for six months out of each year. You actually work in your profession and get paid! In that program it took five years instead of four to get a degree, but it was worth it. I was lucky enough to get a position as an undergraduate research assistant at the National Radio Astronomy Observatory Headquarters in Charlottesville, Virginia.

"So as a teenager I was thrown into a research environment and just loved it. I really thrived on being around scientists who were active in research, and I loved the whole scientific endeavor. I would come to work on a Monday morning and there would be someone who had found something interesting that they wanted to talk about. It was a very exciting experience.

"I've also always enjoyed talking about research, and I'm more than happy to speak to people or make presentations and try to inspire the next generation -- not necessarily to become astronomers, but to consider careers in science, technology, engineering or mathematics. A lot of kids these days don't have good local role models that would allow them to think that maybe they could become a scientist. Or maybe they could become a mechanical engineer or a mechanic on a large structure like a radio telescope. It's important to get out and get the message out."

Q: There have been news reports that consideration is being given to closing the Green Bank Telescope facility for budgetary reasons. Is that true?

Lockman: "This is not our choice. This is something that the National Science Foundation is considering, and it would mean a massive reduction in the radio astronomy capability of the United States. There's no other telescope that can do the majority of the research that is done here in Green Bank. It would be a major loss of scientific facilities for American astronomers.

"We operate the Geen Bank Telescope (GBT) for the National Science Foundation at no charge to the scientists who use it. Any scientist, whether at a small college or a large university, who has a good idea can write a proposal to use the GBT. These are evaluated by independent scientists, and the best proposals get time on the telescope. In the last six years more than 1,000 individual scientists and their students have used the GBT for projects ranging from comets to cosmology. In recent years federal funding for most scientific research has fallen short of what is needed and the pressure on the GBT is symptomatic of a larger problem."

Q: Looking through a telescope seems to be only a small part of astronomy research. What else is involved?

Lockman: "Quite a bit. I'm sitting here at my desk in front of several computers. The amounts of data that we're getting now can be so large that you need fairly hefty computational facilities to make any progress in analyzing them.

"One of the things that we do with astronomical radio signals is to try to turn them into images of the radio sky. If your eyes could see radio waves, how would the sky appear? Our eyes are very good at picking up patterns, and understanding relationships. We understand much more from points on a graph than from the same numbers in a table. The Observatory employs computer specialists who work in data visualization. It's an increasingly important field in astronomy. We have electronics engineers here who build the one-of-a-kind receivers needed to pick up and amplify the very faint

radio waves from space. We have software engineers that specialize in telescope control or in analyzing and processing the data that come in. There are mechanical engineers that design and repair the large dishes. It's a diverse bunch that we have here and it takes a lot of different kinds of talent to run an observatory."

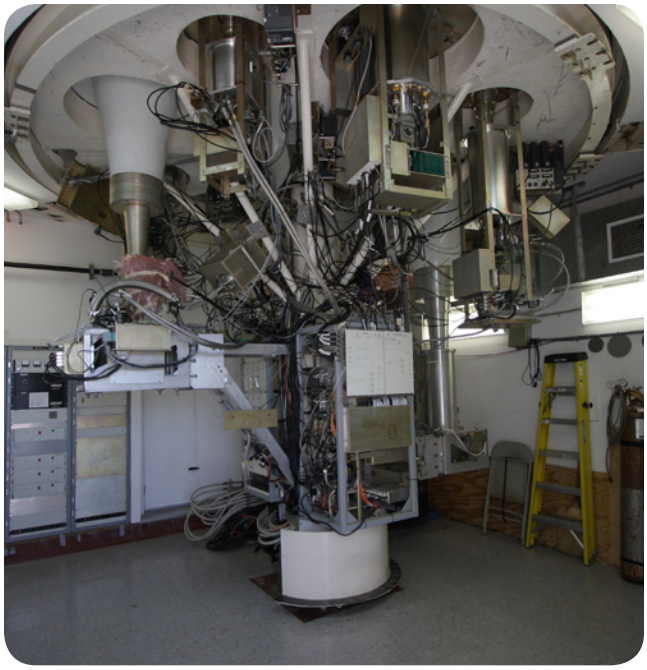
Q: With the sheer amount of data being accumulated, is it possible that things are missed only to be discovered in future analysis of the data?

Lockman: "The data go into an archive so that people interested in looking at it again, or reprocessing it, can do so. But this brings up an interesting point related to your previous question. There are objects in space that we call pulsars: the collapsed remnant of a star that has exploded. A pulsar has about the same amount of matter as our Sun, which is a lot, but its size is just a few miles across. It's very dense. Pulsars emit beams of radio waves. They rotate like a lighthouse and the radio beams sweep across the Earth. We can see pulsars to great distances and they are like little clocks out there in the Milky Way.

"We're always interested in finding new pulsars, in new locations, and with new properties. But searching for pulsars is a very data intensive process. Once you scan an area of the sky with a radio telescope, looking for the faint pulses that might only be a milli-second long, you have this huge amount of data. Turns out that it is very efficient to use the human eye to look at this pattern to distinguish a signal from the noise.

"Scientists and educators at Green Bank and West Virginia University are collaborating with teams of high school students to examine pulsar search data and try to discover new pulsars. They've had really good success so far. Its genuine discovery, and once a team from a high school thinks they've found something, there's a protocol they go through to confirm it. Eventually they get to use the Green Bank Telescope for re-observation and ultimate confirmation. A paper is just now being published in the *Astrophysical Journal* about the first half dozen or so new pulsars found by these teams of students.

"That is an example of high school students who are interested in science and doing real research. It's not that different from how I started and it's great."



The receiver room at the top of the Green Bank Telescope.

Photo: Walter Scriptunas II

Q: One of the items you've been studying recently is a giant cloud of gas. What have we learned about it?

Lockman: "That's a very interesting gas cloud. Its existence has been known for about 50 years. But until recently no one quite understood where it was or what it was.

"Using the Green Bank Telescope, we were able to map its hydrogen with the highest precision that has been possible. And what looked like a blob in earlier studies was revealed to be this huge structure that resembles a comet.

"We're begining to get an understanding of this very massive gas cloud -- a million times the mass of the Sun -- that is on a trajectory to intersect the Milky Way in maybe 30 million years. It's liable to cause bursts of star formation on the other side of our galaxy. It's a fascinating object and there is so much we don't understand about it yet."

Q: What's left out there to discover for the next generation of astronomers?

Lockman: "By now the astronomers of the world have taken a quick look at the entire sky. But what we've realized is that there are things out there that could be flickering on and off, and that were off when we were looking at them.

"That's the whole new area of time domain astronomy, just getting started, monitoring the sky over and over again, and looking for these odd bursts of light, radio waves or X-rays that may be coming from objects we haven't discovered yet.

"There's a huge amount of research to do as well in simply accounting for the basic constituents of the universe as they evolve over time. We know that there is this stuff called dark matter. Dark matter is what holds galaxies together. It supplies the gravity that keeps the Sun from flying out of the Milky Way, yet we really do not have a clue as to what this stuff is.

"It's amazing to me how much we have learned during the course of my career. And yet knowledge in one area doesn't always connect up with knowledge in another. I have this image of islands of understanding sitting apart in an ocean of ignorance. We can see the islands, but we don't necessarily have the bridges between one island and another island. And new islands appear all the time. There's still a lot of discovery to be made and a lot of these connections to be made."

Starting in astronomy

beginner guide to stargazing for students

By Mike Barrett

buying your first telescope

A telescope is a spectacular scientific instrument that is accessible to people of all means and abilities, and opens up the wonders of the Universe. Like all things technical, it is a tool and you will only be able to use it with the correct training. Also, typically, there are different types, for different uses, making selection of your first telescope a little confusing. So how do you choose which one to buy first?

As usual the first thing to decide on is your budget. You will find that the price range of equipment is phenomenal. From just a few dollars to many thousand dollars. There are bargains to be found so do your research carefully.

telescope technologies

The next thing to decide is what you want to use the telescope for. There are two basic technologies used to make telescopes: refraction and reflection.

A refractor telescope uses two lenses to collect and focus light at a certain point. This design is the classic telescope invented in Holland and made famous by Galileo in 1609, and also used by Admiral Nelson. This is a handy instrument capable of being used for terrestrial observation as well as celestial.

A reflector telescope uses mirrors to gather and reflect light. Typically there will be two mirrors, a large primary mirror and a smaller secondary mirror. The primary mirror determines how much light is received, and the secondary mirror directs the image to the eyepiece. There are a number of different types of reflector telescopes mainly differentiated by the path of light through the instrument. The two most common types are Newtonian and Cassegrain. The Newtonians focus and direct the light to the side of the optical tube, whereas the Cassegrains reflect it back to the bottom of the tube allowing for a more compact design.

how telescopes work

Before going any further it is worth understanding how telescopes work. Your first thought may be that you need to magnify distant objects to make them visible. This is wrong. A star that appears as a dot that is two light years away will still be a dot magnified 1,000 times. The purpose of a telescope is to gather more light than the human eye can see and condense it. This then brings more faint objects into view.

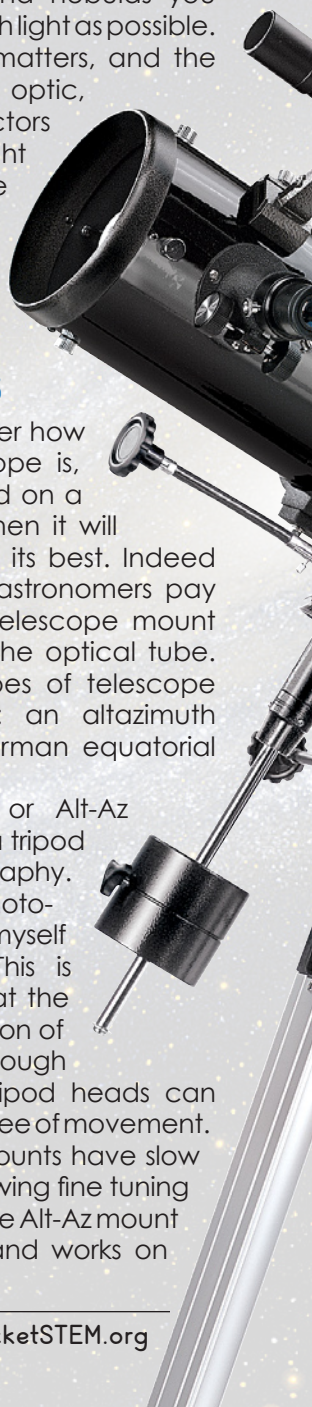
So a telescope is effectively a big light bucket. This is an important concept to grasp. In photography you need long focal lengths to capture distant images, at the expense of the amount of light received in the camera. The trick here is to gather as much light as possible then focus an eyepiece on it. The magnification is done using the eyepiece in a similar way that a magnifying glass works.

what are your objectives?

The next thing to consider is what you want the telescope for? It may seem like a silly question, but looking at craters on the moon is vastly different to photographing faint nebula clouds thousands of light years away.

The moon and the planets are the brightest objects in the sky and need less light gathering capacity than other stellar subjects. If the primary purpose of the telescope is planetary observation then a Cassegrain or refractor style of telescope is ideal. These offer longer focal lengths allowing for greater magnification.

When looking at star clusters, distant galaxies and nebulas you need to get as much light as possible. This is where size matters, and the larger the primary optic, the better. Reflectors offer very good light gathering/price performance, but at the expense of physical size.



solid foundations

It does not matter how good your telescope is, if it is not anchored on a solid foundation then it will not be working at its best. Indeed many advanced astronomers pay far more for the telescope mount than they do for the optical tube. There are two types of telescope mounts available: an altazimuth mount, and a German equatorial mount.

The altazimuth or Alt-Az mount is similar to a tripod used for photography. Indeed I use a photographers' tripod myself when travelling. This is a little crude in that the control of the position of the telescope although more expensive tripod heads can give some fine degree of movement. More expensive mounts have slow motion cables allowing fine tuning of the telescope. The Alt-Az mount has two controls and works on

the principle of compass direction (azimuth) and elevation (altitude), effectively moving the tripod up and down, or left and right. To keep an object in view over a period of time both controls need to be adjusted.

The German equatorial mount, also known as an equatorial mount or GEM, is a much more complex mounting system that takes into consideration the movement of stars around the celestial pole. Setting up the equatorial mount can be complicated as one axis of the mount needs to point to the polar star. Once properly aligned the stars can be tracked just by using a single control. This control can be driven with a motor enabling the precise tracking of stars throughout the night. This type of mount is ideal for astro photographers as it keeps the aspect and relationship of the stellar objects aligned over time.

Another type of mount available is a Dobsonian. This is actually a variant of the Alt-Az mount, but with the base actually on the ground with a swivel plate. The telescope drops onto this and there are friction plates to control the elevation. This type of telescope looks like a canon. One advantage of a 'Dob' is that it can be very large, but still controllable by hand.

going high-tech

So far everything has been 'low tech' in as much as it is pure physics and engineering. To use the telescope you need to understand the movement of the stars and be able to find and hone in on the objects that you want to view. Wouldn't it be nice if you could press a few buttons and the telescope would move to your area of interest and keep it in view as the earth rotates?

The advent of the GOTO mount has achieved this. To the purists this is sacrilege, but for observers with limited time and experience it is a boon. The technology does make us lazy and prevents us learning the full majesty of the night skies, but on the other hand it opens up a new frontier to those who do not have the time or the inclination to learn the constellations.

The GOTO mount needs to be calibrated each time it is used. This lets the electronic wizardry know exactly where it is and what the time is. From that it knows where all the stars are and which ones can be seen. Once set up all you need to do is press a few buttons and the mount will orientate the telescope to your target object and then start tracking it through the night skies.

managing your expectations

When we look at astro images in the media and online we often see wonderful multicoloured pictures in clear sharp detail of stars drifting in clouds of nebulosity. I had expectations of seeing something like this when I looked through my first telescope. I was wrong! These images are created by sensors capturing photons for many hours and then being processed and enhanced in computers. When you look through the eyepiece your eye must collect and process all the available light instantly. The fainter the light the less you will be able to see.

This is one of the reasons astronomers use 'dark sites' and accustom their eyes to the dark. It takes around 20 minutes for your eyes to get used to the dark and your pupils fully dilated. This allows more light to reach the retinas letting you see the finer details. It doesn't end there though. Your eyes are adaptive and in low light will switch to monochrome, letting you see more but at the expense of color. This is the reason that size matters in the telescope primary lens or mirror. More light getting to the eye means more detail.

This does not mean that you will not be able to see some great objects. Of course the Moon is always stunning. Its brightness means that even the cheapest and smallest telescope will render detail. The brightest deep space objects can be seen with the naked eye, in particular Orion and the Pleiades. Training the telescope on these will reveal a lot of detail. The clouds of nebulosity in Orion and the stellar dust around the stars in the Pleiades can be spectacular.

summary

A telescope is a light bucket. The bigger the bucket the more you can see. If you are looking for portability then a Cassegrain style of telescope is good; for performance then a reflector would be my choice. Getting bang for bucks, the Dobsonian is hard to beat. For an all round performer, a refractor is one to look at. To make things easy then a GOTO mount helps enormously.

The telescope is the first part of the astronomical experience. Most telescopes will come bundled with one or more eyepieces, but it is the eyepieces that can make all the difference to your observing experience. I will be covering eyepieces in a separate article.

When I started in astronomy my personal kit was a 90mm (3.5") Spotting Scope with a Maksutov-Cassegrain design. It mounts on my photography tripod and is light and portable. This was very quickly joined by a 5" Newtonian reflector on a GOTO mount, it is less portable but better for deep sky observing. Both of these were obtained for just over $500, though I have spent somewhat more on accessories since.

orion the hunter

By Mike Barrett

The constellation Orion is an easily recognisable star grouping visible in the northern hemisphere in even the most light polluted skies. Orion is depicted in many ways: as a hunter wielding a club and shield, brandishing a sword and shield, or clubbing a lion. These however are just visualisations interpreting a pattern in the stars.

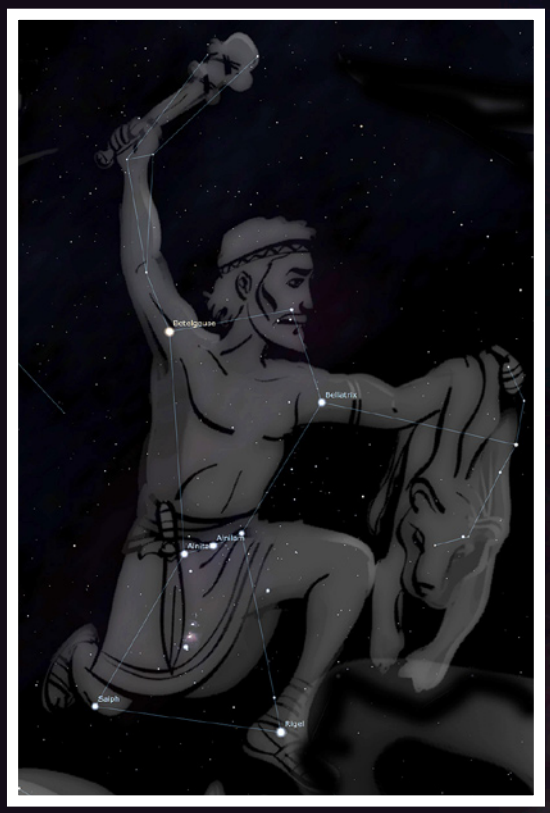


Image: Stellarium

The best way to identify Orion is by finding the two bright stars Betelgeuse and Rigel. If you draw a line between these stars there should be a line of three stars in the middle. Even on a night with poor visibility you should be able to see these stars.

Betelgeuse is Orion's shoulder, and Rigel is his leg or ankle. The three stars in the middle Alnitak, Alnilam, and Mintaka (left to right) form Orion's belt. To the right of Betelgeuse above and to the right of the belt is Bellatrix forming Orion's other shoulder. Drawing a line through the middle star in Orion's belt is Saiph representing Orion's knee.

On a darker night with good visibility you will be able to see some of the fainter parts of the constellation. The most interesting is the Great Nebula in Orion. The Orion Nebula can be seen just under Orion's belt and will look like a smudge or cloud to the naked eye.

This nebula is a good example of a star forming region in the galaxy. What you are actually seeing is a cloud of stellar dust about 24 light years across and 1,340 light years away.

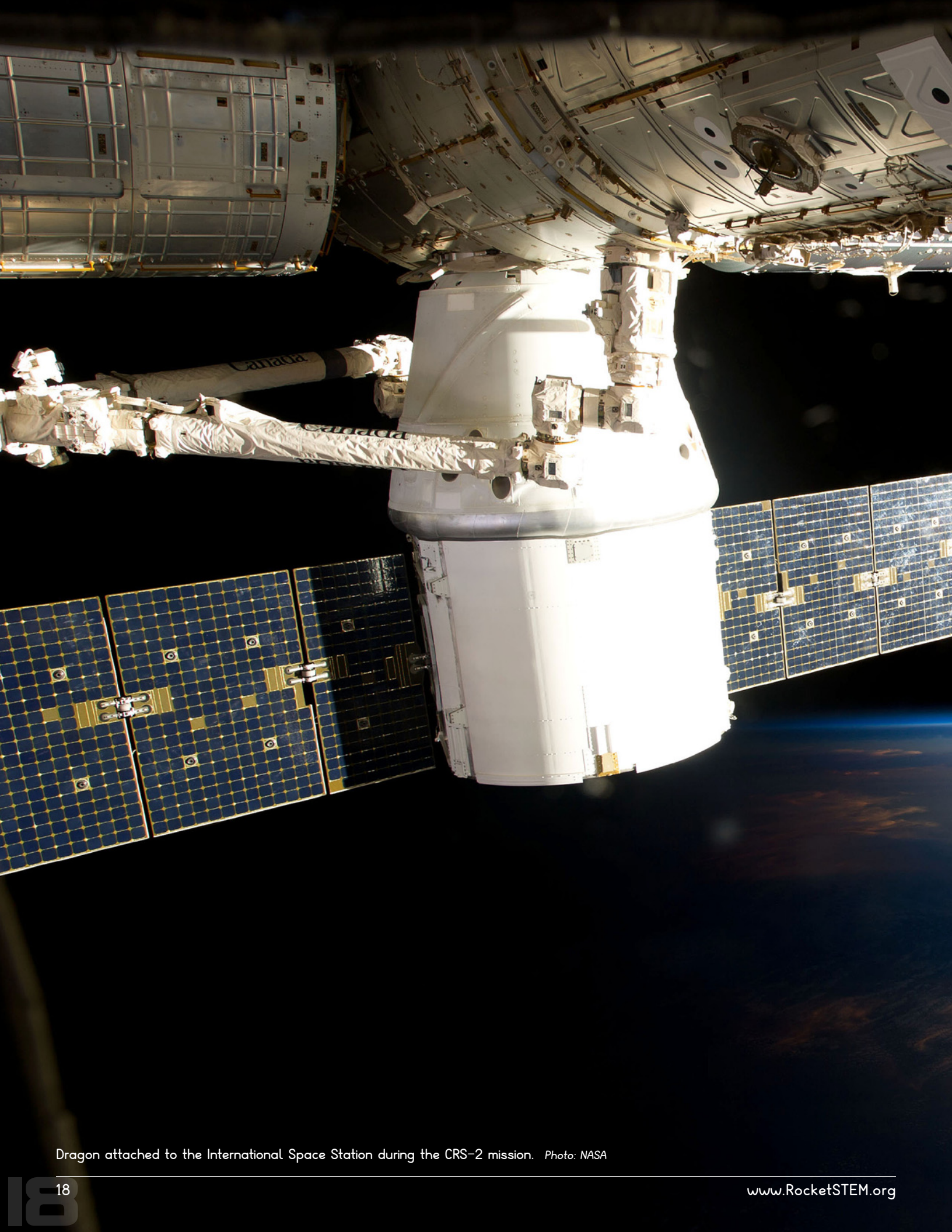
Looking at the nebula with different instruments reveals ever increasing amounts of detail. Starting with the naked eye you can see a gray smudge, moving up to binoculars the cloud starts to form in your vision. With a low powered telescope you can see the nebula and a few stars, but the stars are all merged together into a single light source.

As you use ever increasing magnification eyepieces or more powerful telescopes other details start to emerge and you can start to see some of the individual stars in the nebula. With the highest magnification you will see the trapezium. This at first appears as four stars arranged in a rectangle. However, those of you with sharp eyes will be able to separate out all six stars in the cluster.

Up to now what we have seen has all been in monochrome. The vivid colors of the pictures that you see of the nebula are only obtained using long exposure photography. The long exposure capability of the camera allows more photons of light to be recorded thus capturing the colors of the nebula.

The human eye is a very clever device. In order to compensate for low light levels it switches to monochrome to allow more detail to be seen. This allows us to see some of the faint details of the celestial wonders, but not to appreciate their full glory.

Image: NASA/ESA/M. Robberto (STScI/ESA)



Dragon attached to the International Space Station during the CRS-2 mission. *Photo: NASA*

From zero to orbital velocity

Dragon delivers to ISS

Story by Sherry Valare

Engines roar to life (above) as a Falcon 9 rocket begins a journey to space that will send the Dragon capsule on a cargo run to the International Space Station. The rocket clears the pad (below) as it rises above the horizon of the Atlantic Ocean. *Photos: Anthony Fitch*

"3...2...1...and liftoff of the Falcon 9 rocket and Dragon, SpaceX continues America's mission to re-supply the International Space Station from U.S. soil."

In 2006, SpaceX, a private rocket and spacecraft development company led by Elon Musk, began plowing the path for a new generation of spaceflight, with the launch of the Falcon 1 rocket. In June 2010, with the conclusion of the Shuttle era around the corner, its successor, Falcon 9, stood upon the launchpad poised to make its grand entrance into the aerospace world. The Falcon family was introducing itself, one test flight at a time. I was a witness to the Falcon 9 taking its maiden flight that day, and I was immediately enchanted with this 'little company that could'.

The sound of the launch being broadcast on the radio filled the air. As the countdown came to an end, I watched the Falcon 9 come to life as it lifted up and away from my view. It was a monumental event for SpaceX and several successful landmark missions would soon follow this historic moment.

In December 2010, the Dragon, a reusable spacecraft designed to eventually carry crew and cargo, was launched aboard the Falcon 9. It was then safely returned back to the ground, making SpaceX the first commercial company to effectively carry out the launch and recovery of a spacecraft. On another demonstration flight in May 2012, Dragon was delivered to orbit again by the Falcon 9 to berth with the International Space Station, be opened by the ISS crew and emptied of the supplies inside, then detach and return safely to Earth. The completed mission was a flawless display of Dragon's capability.

In October 2012, Dragon would be delivered again to the ISS, this time on its first official cargo re-supply mission (CRS-1). This was the first of 12 re-supply missions SpaceX was awarded by NASA. Though a problem occurred when one of the first stage engines shut down on the Falcon 9, its primary job of delivering Dragon safely into orbit after adjusting its flight path was still accomplished. It again successfully berthed to the ISS, and remained attached until it returned to Earth, landing in the Pacific Ocean.

On March 1, 2013, I had the privilege of witnessing the second commercial re-supply mission (CRS-2) from 525 feet above the ground. From the top of the roof of the Vehicle Assembly Building, with the wind whipping the chilly air around, Launch Complex 40 was bathed in the late morning sunlight when intermittent cloud cover was forgiving. Falcon 9 stood proud with Dragon, ready to fly. Though the rocket is on the smaller side, it has a powerful presence. As Shakespeare wrote, "Though she be but little, she is fierce!"

I had an eagle-eye view as the Falcon 9 rose up from its launchpad, with Dragon leading the way through the cloud covered sky. Its sound punched through the wind, letting out a low intense rumble as it headed for orbit, getting louder and louder with each second that passed. As the rocket rose higher, its sound started to fade, until it completely disappeared. The Falcon 9 had performed its job – and it was time for Dragon to commence its part of the mission. Soon it would meet up with the ISS for the delivery of supplies and experiments to the crew.

Dragon in orbit during the CRS-2 mission. *Photo: NASA*

The arrival of Dragon to the ISS was delayed due to a minor setback with its oxidizer tanks, but the ground crews worked quickly to identify the problem, and get it back on track. On March 3 it was successfully captured and berthed to the ISS. It delivered 2,300 pounds of cargo to the residents on board, stayed attached for 22 days, and was then filled with over 3,000 pounds of cargo to carry home. On March 26, Dragon completed its mission and returned to Earth. It splashed down in the Pacific Ocean a few hundred miles off the coast of Baja California (which is a neat coincidence since "baja" means "come down" in Spanish).

SpaceX has ambitious plans for the future. Missions are already scheduled on its manifest through 2017 for several customers including the Canadian Space Agency, Orbcomm, Iridium Communications, Asia Satellite Telecommunications and Thaicom. These re-supply, satellite placement and launch services will also continue to serve NASA along with the other companies that have placed their trust in SpaceX. Manned flights may begin to Low Earth Orbit (LEO) in 2015.

Opinions about the ending of the Shuttle program vary. Some feel that we were not prepared to end it without having something else in the works. Some feel that it motivated us to look towards the future. With determined companies like SpaceX pushing forward with success after success, they demonstrate their competency and capability and create a standard for other commercial companies entering the race to live up to. SpaceX provides us with an exciting snapshot of the future, as they continually prove to the world, that determination can decide destiny.

Fast Facts

The name game:

The Falcon 9 got its name from the Millennium Falcon – the spacecraft commanded by Han Solo in the original Star Wars trilogy. The '9' comes from the nine first-stage Merlin engines that propel the rocket. Dragon was named after the fictional character Puff the Magic Dragon because in 2002, critics thought that the original goals SpaceX had in mind seemed to exist more in the realm of make-believe.

It's only rocket science:

The Falcon 9 was developed entirely in the 21st century, from start to finish. It is all-American, with its design, development, and testing completed in the United States by SpaceX. It took only four and a half years to take the idea off of paper, and turn it into a launched rocket, with a cost of less than $300 million. In order to minimize the amount of stage separations, and therefore reduce the probability of a failure during flight, the Falcon 9 is designed with only 2 stages. In the event a first stage engine fails, the rocket can still carry out its mission. At sea-level, the engines provide 855,000 pounds of thrust, increasing to almost 1,000,000 pounds of thrust as it blasts through the atmosphere. The Falcon 9 has a 100 percent primary mission success rate.

Capture a Dragon:

When the Dragon spacecraft successfully berthed to the International Space Station in May 2012, it was the first commercial spacecraft to ever accomplish this feat.

Give me some space:

For cargo transport, Dragon has a pressurized capsule and an unpressurized trunk. It can carry 7,297 pounds of cargo between the two spaces.

Powering the Dragon:

During flight, two solar array wings power Dragon. The eight panels produce over 5 kilowatts of power, but when Dragon enters darkness, (about 40% of the time when it is in low-Earth orbit) its surplus power takes over and recharges its batteries.

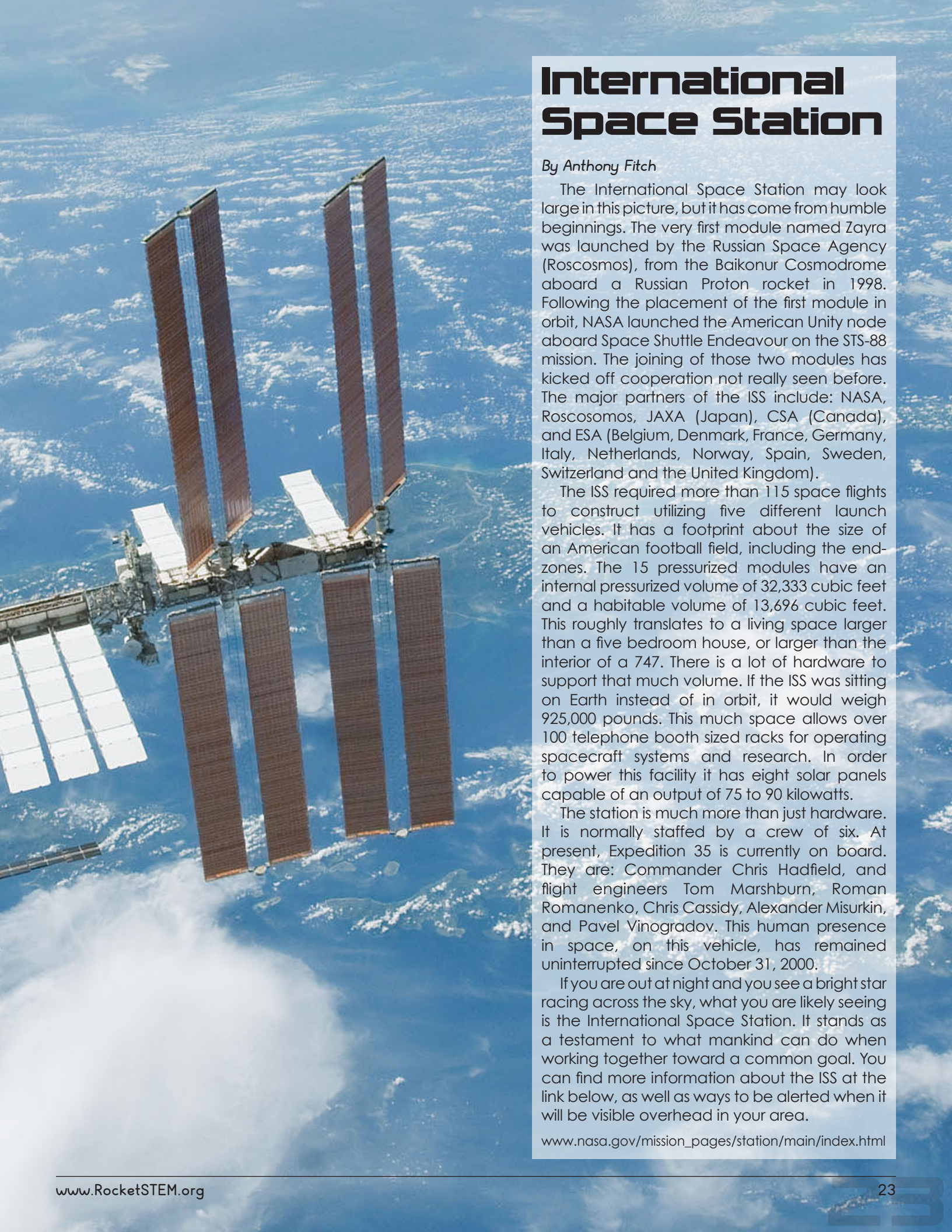
Withstanding reentry:

It was built with a heat shield made of PICA-X, which can withstand the extreme heat generated upon reentry from a lunar return mission. The design of the heat shield was completed by NASA and brought to life by SpaceX. The spacecraft's shape creates lift during reentry, while roll control is provided by 18 Draco thrusters, ensuring it stays on course for a smooth landing.

A manned future:

For now, it only carries cargo, but it is being refined to carry a flight crew as early as 2015.

Backdropped by Earth's horizon, the International Space Station is photographed by an STS-130 crew member on Space Shuttle Endeavour in 2010. *Photo: NASA*



International Space Station

By Anthony Fitch

The International Space Station may look large in this picture, but it has come from humble beginnings. The very first module named Zayra was launched by the Russian Space Agency (Roscosmos), from the Baikonur Cosmodrome aboard a Russian Proton rocket in 1998. Following the placement of the first module in orbit, NASA launched the American Unity node aboard Space Shuttle Endeavour on the STS-88 mission. The joining of those two modules has kicked off cooperation not really seen before. The major partners of the ISS include: NASA, Roscosomos, JAXA (Japan), CSA (Canada), and ESA (Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom).

The ISS required more than 115 space flights to construct utilizing five different launch vehicles. It has a footprint about the size of an American football field, including the end-zones. The 15 pressurized modules have an internal pressurized volume of 32,333 cubic feet and a habitable volume of 13,696 cubic feet. This roughly translates to a living space larger than a five bedroom house, or larger than the interior of a 747. There is a lot of hardware to support that much volume. If the ISS was sitting on Earth instead of in orbit, it would weigh 925,000 pounds. This much space allows over 100 telephone booth sized racks for operating spacecraft systems and research. In order to power this facility it has eight solar panels capable of an output of 75 to 90 kilowatts.

The station is much more than just hardware. It is normally staffed by a crew of six. At present, Expedition 35 is currently on board. They are: Commander Chris Hadfield, and flight engineers Tom Marshburn, Roman Romanenko, Chris Cassidy, Alexander Misurkin, and Pavel Vinogradov. This human presence in space, on this vehicle, has remained uninterrupted since October 31, 2000.

If you are out at night and you see a bright star racing across the sky, what you are likely seeing is the International Space Station. It stands as a testament to what mankind can do when working together toward a common goal. You can find more information about the ISS at the link below, as well as ways to be alerted when it will be visible overhead in your area.

www.nasa.gov/mission_pages/station/main/index.html

Photo: NASA

Photo: Nicole Solomon

Photo: NASA/Carla Cioffi

NASA astronaut Kevin Ford (top left) watches a water bubble float freely between him and the camera, showing his image refracted, within the Unity node of the International Space Station.

Marshall Porterfield, Life and Physical Sciences Division Director at NASA Headquarters (right), spoke about the human body in microgravity and other life sciences.

NASA Socials:
An out of this world journey

By Nicole Solomon and Tim Breitbach

Neil Armstrong wasn't the only person who took a giant leap in space. Over the course of the last several decades, humanity has reached further into space than ever before. But one of our most astonishing achievements is actually just over our heads – the International Space Station (ISS). The ISS is an unprecedented partnership between governments, agencies and commercial entities – a leap many never thought possible. And yet, if the astonishing exploration, technology, experiments and scientific discoveries do not trickle down to the taxpayers funding such adventures, what's the point? That is where NASA Socials come into play.

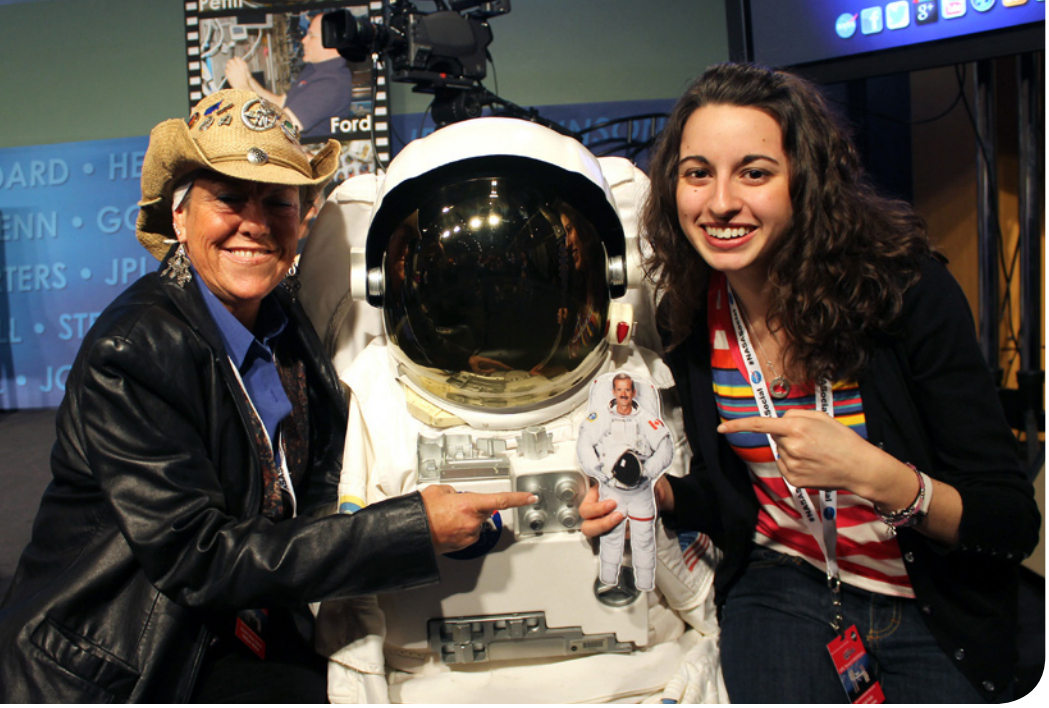
NASA Socials take advantage of the reach of today's vibrant social media platforms to bring the science and exploration of space down to Earth, in a way that is as informative as it is engaging. Events are designed to allow individuals to interact with people and processes to which they might otherwise never have access. And in doing so, NASA makes space accessible to the people who most find it fascinating. NASA held its first social media event, a Tweetup, at the Jet Propulsion Laboratory in Pasadena, California, in January of 2009. Since then, thousands of participants have generated social content seen by hundreds of millions of people.

"The view of Earth from space really gives the sense that the planet is a living, breathing organism."

– *Ron Garan*

"Social media has changed the way NASA communicates with the public," said Bob Jacobs, NASA Deputy Associate Administrator for Communications. "It allows us to connect directly with people. Historically, the traditional media has acted as a filter in disseminating information about our activities. As news organizations limit or eliminate space beat reporters, we've seen an explosion in technology that allows us to create conversations directly with the public. It's fascinating to see and experience."

This past February, Washington, D.C. held its second annual Social Media Week, a festival featuring independently curated speakers, panels, workshops and parties celebrating tech and social media. The ISS Science Social was designed to spread the word about the groundbreaking research currently taking place aboard the football-field sized structure, some 240 miles above Earth. During the event, 150 of NASA's social media followers had the unique opportunity



Canadian astronaut Chris Hadfield was in orbit commanding the ISS during the NASA Social, but one of the attendees made certain a small cardboard likeness of him was present on the ground for the event. *Photo: Nicole Solomon*

to talk with three of the six current crew members — NASA astronauts Kevin Ford and Tom Marshburn, and Chris Hadfield of the Canadian Space Agency — and, in-person, astronaut Don Petit; NASA Associate Administrator for Human Exploration and Operations, Bill Gerstenmaier; Director of NASA's Space Life and Physical Sciences Research and Application Division, Marshall Porterfield; and NASA Associate Space Station Program Scientist, Tara Ruttley. All were a huge hit with those in attendance.

Blogger Jamie Rich commented, "NASA Socials are a blast! You get access to the coolest stuff — astronauts, scientists, and engineers. Even if you're a not a space geek like me, it's super fun."

Rich (@jamerz3294) also asked the first question for his nephew, Thomas: "How much time does the International Space Station take to perform a collision avoidance maneuver?" The answer: the ISS can now do a reboost to avoid space debris in just six to seven hours.

Other questions ran the gamut from how much oxygen is used daily, to unintended scientific discoveries, how weightlessness affects the body, how the astronauts utilize math in their work, and the condition of the 32 fish flown to the ISS last year. When one young woman asked, "When do you think fat people will be able to go to space?" the astronauts diplomatically stated that "hopefully soon everyone will be able to get this incredible experience we are lucky enough to be part of."

As eager as the attendees were to devour the information being presented, the NASA employees were just as eager to share their experiences, and do their best to answer the myriad of questions thrown their way.

"Generally, what we do is kind of out there and out of reach for most people," said Don Petit. "But to interact with them first hand, to have them communicating with the ISS, to see the looks on their faces as they were doing so…it's invigorating for the people on the ground and in space alike."

When asked about the communication challenges NASA faces with the public, Bob Jacobs said candidly, "I think we need to do a much better job talking about the relevance of the work going on in space. The crew is working on vital research that impacts us here on Earth and will help inform our future beyond low-Earth orbit. People who claim to be 'green' should closely study the space station. We recycle everything. But we have to talk about why we're up there and what the research we're doing means. The International Space Station is a model for international cooperation. When you think about all the agreements, the nations involved, and the technology innovation needed to bring it all

During a NASA Social event in the nation's capital, 150 social media followers went on a tour of the Smithsonian Institution's Air and Space Museum. *Photo: Nicole Solomon*

"What we are learning in space is going to help us explore the solar system. The research we are doing on the station is making life better on Earth. We are studying our planet 24 hours a day."

– @Astro_Ron

It may be a while before NASA puts out a call for farmers to produce space crops (top right), but that's not to say that astronauts may not one day be growing a few of their own food stuffs aboard the International Space Station. *Photo: NASA*

Astronaut Ron Garan (top left) poses while taking photos of Earth from within the ESA-built Cupola aboard the ISS.

Photo: NASA

NASA Social attendees (bottom) pose for a group photograph following a NASA Social exploring science on the ISS on Feb. 20.

Photo: NASA/Carla Cioffi

together, it's an amazing feat of engineering and science."

The ISS Science Social was just the first such NASA event during D.C.'s Social Media Week. The other was a Google+ Hangout, which allowed attendees to log in to a panel discussion and "hang out" with astronauts Ron Garan and Nicole Stott.

According to NASA, the three primary goals of the ISS are educating the children of today to be the leaders and space explorers of tomorrow; returning the knowledge gained in space research for the benefit of society; and enabling future space exploration missions. What is so special about these social media events is that they mirror the very mission of the space station itself.

Ron Garan, who has more than three million followers on Google+ and 95,000 followers on Twitter, is using social media to change the face of NASA. The founder of Fragile Oasis said, "The research we are doing on the station is making life better on Earth. We are studying our planet 24 hours a day. The view of Earth from space really gives the sense that the planet is a living, breathing organism. And I have a responsibility and an obligation to share my experience of living in space with as many people as I can. Being an astronaut, we are basically ambassadors of humanity. What we are learning in space now is going to help us explore the solar system tomorrow."

A conversation with

SKYLAB'S ED GIBSON

America's first space station, Skylab was launched into orbit on a Saturn V rocket in May of 1973. Three manned missions to the outpost were immensely successful. Repairs made to the orbital station during several spacewalks ultimately proved that it was possible for astronauts to conduct work in outer space, which gave NASA the confidence to eventually follow Skylab with on-orbit assembly of the International Space Station.

Astronaut-scientist Edward G. Gibson, who earned a doctorate in engineering with a minor in physics, was the Science Pilot for the third and final mission to Skylab in late 1973, returning to Earth in February of 1974. Being the last humans to board Skylab, the crew was kept busy from day one, but still found time to enjoy the view.

Astronaut Edward Gibson spoke with *RocketSTEM* about the final Skylab mission and other topics. Here is the condensed interview.

Gibson: "Well, let's see. What was it like? How do I ever give you a concise answer to that one? The beginning, of course, is always exciting, the liftoff on through rendezvous and docking. Once you get inside the station, you encounter two challenges. First, there is a lot of work to get started. Second, you also have to be careful that you don't move too fast or you'll get space sickness. Jerry [Gerald Carr], who was the commander, and myself, did alright on that. Bill [William Pogue], the Pilot, did get sick and he was sick for a number of weeks, which slowed him down. That's just the nature of the animal unfortunately and hard to predict.

"We got up there and immediately had a lot of work to do because the previous crew had done a great job. They started slow and finished fast. Even though Ground Control tried to make several allowances, they really started us a little faster than we were ready for. We ended up being behind the scheduled activities as opposed to ahead of it, which is where you always like to be.

"We sorted through that and by the time the smoke cleared at the end of the mission we had accomplished the same average work per day that the previous crew had done.

"You never get tired of looking out the window. That's something I wish everyone could do. If people could experience zero gravity while looking out the window, they would have a different perception of our home planet. Pictures are great, but they don't really give you the same physical and intellectual perspective."

For all astronauts, reentering the Earth's atmosphere and adapting to gravity once again is always a tough task, both mentally and physically.

Gibson: "After you burn the engine and you slow up just slightly, you gradually start dropping down toward the atmosphere. The first thing you notice is a violet glow, a very soft glow.

"Once we got down low and slow enough that we could pop our drogue chutes and then the main chutes, I thought, 'Well, we're back to one gravity.' But I still felt like we were pulling three Gs. Without any gravity for three months, it was tough for the body to get used to it again. It was a rude awakening and disappointment actually.

"When we finally hit the water, it was a good firm slap. We flipped upside-down so we had to inflate airbags that popped us upright. That was probably the most uncomfortable part of the whole flight: bobbing up and down on the ocean in a closed, damp cabin, hanging in the straps with the heat of reentry soaking back in. There was no imminent danger to it. It was just uncomfortable.

"After you flip upright you are pulled up onto the carrier deck. Immediately, as you are laying there and then when you try to get out, you feel more disappointment, at least I did, because I realized that for the rest of my life, no matter how hard I push off, I can no longer float. And no matter where I go, once again, I have to haul along tremendous amounts of meat and bone. Rolling over at night turns into a real engineering challenge.

"You take your movements for granted now because your body and your mind have adapted to it. But after not having to do that for a while, it is like being down here and having lead weights tied all over your body.

"It takes around two hours before you can walk stably, but you still have to walk with your feet wide apart.

"After two days, you could move around pretty well. And then you got close to preflight levels of stability after around two weeks, so from that standpoint we were pretty good."

Luckily for the Skylab residents, NASA had begun to understand the importance of exercise while in orbit and provided the crew with crude, but functional, workout devices.

Gibson: "We had a bicycle Ergometer, which was used primarily to keep the cardiovascular system in shape. That worked pretty well. We had Exergenies, essentially resistance devices, that were like lifting weights back down here on the ground.

"We also had what I call a "poorman's treadmill." Right now they have folks living up there in luxury with a first-class treadmill. We didn't have that available so Bill Thornton, who was an ingenious doctor that later flew on some Shuttle flights, came up with a way to hold us down to the deck with about our own weight by putting elastic straps over our shoulders and then a thin Teflon sheet about two feet wide and four feet long under our feet. In that arrangement we could walk or run by letting our feet slide over the Teflon. That helped keep some of the muscles in shape in our hips and legs that we wouldn't have been able to do otherwise. It worked out pretty well.

"We exercised about an hour and a half every day, which was longer than the previous crews had to exercise, so we came back in slightly better condition."

Despite advances in exercise equipment for use in zero gravity, Gibson believes that bone loss during a manned mission to Mars might still be an issue.

Gibson: "One of the real worries, of course, is going to Mars or on some other long duration mission where you are in zero gravity continuously. First of all, just landing on Mars and being able to stand up and maneuver around could be an issue. Second, calcium loss from the bones could also be a problem. NASA felt that, on the average, we would have been OK up to about a year and a half. A bone is just like a muscle in that, if you exercise it, it retains its strength; for a bone, it's its calcium. And, of course, the parts you don't exercise in zero gravity like you do down here are the legs and the hips.

"We came back [from Skylab] in reasonable condition. I also think they've developed some effective ways to circumvent most of these problems. I'd hate to see us have to go to a rotating space station, because I enjoyed zero gravity!

Ed Gibson operates Skylab's solar telescope array from the control console in the multiple docking adapter. One hand grips the table to keep him from floating away.

Photo: NASA via Retro Space Images

Gibson spent more than 15 hours outside Skylab during three spacewalks, on top of setting a world record with his crewmates for the longest time spent in space, which was a record that was not topped until 1978 by the Soviet Union.

Gibson: "I also really enjoyed the EVAs, the spacewalks. You really get to see the Earth as you don't see it from inside, and the feeling of height is a little bit different.

"I don't know to give you that feeling of height other than through an analogy. Let's come back to Earth and go up to the top of a tall building where you look out. The Empire State Building or Sears Tower will do. It's pleasant and relaxing. But then let's open the window and walk out to the end of a long springboard where a steel fisted Hulk Hogan grabs you by your ankles and holds your head down. Now, intellectually, you know you'll never fall, and even though you're at the same height as you were inside, you've got to admit it feels a bit different.

"You get that same feeling on the spacewalk just more of it. You just glide over Earth at a very serene five miles per second. And the laws of Sir Isaac Newton give you full intellectual confidence that you're up there to stay. But when you move away from the station, look down hundreds of miles at Earth and don't feel or see anything else around you, you wonder if that Newton guy was maybe…. just a little bit wrong. Then you take the smile off your face and get back to work."

The Apollo Telescope Mount (ATM), a solar observatory attached to Skylab, was the principle responsibility of Gibson during his mission. The ATM was able to make observations at wavelengths from extreme ultraviolet to infrared.

Gibson: "The ATM started out back in the early days as we were pulling together the components of what was to become Skylab, previously called the Apollo Extension System. The solar experiments of ATM were to be done automatically and mounted on the Apollo capsule.

"But then, when space station came along, they recognized that here was a way to get in-place humans involved in the acquisition of

solar data using ATM's seven different instruments. ATM became a whole separate module that looked at the Sun in X-rays, ultraviolet and white light. We were also able to look at the Sun's corona at any time by creating our own artificial solar eclipse. We really were able see the Sun as never before.

"The most enjoyable part of it was that we had television displays onboard in which we could see what some of the instruments were seeing, which helped improve the quality of data we acquired.

"One observation we really wanted to make was of the very early phase of a solar flare so that the investigators could get a better understanding of what happens in its initiation phase, what sets it off, and how we can better predict it. We finally came up with precursors that we could see in the ultraviolet displays that would tell us that the active region that we were looking at was becoming more unstable and about to pop. Towards the end of the mission we got reasonably good at that.

"We did get the early phases of a flare and we also saw the Sun as few people have ever seen it before. We were able to get a lot of information about bright points, coronal mass ejections, early phases of a flare, better definition of an active region and the progression in time of all of these phenomena.

"The ATM kept me sane, because when you are up there for that length of time, you want some mental challenges. Just pushing buttons by rote gets old after a little while. I enjoyed having that kind of mental challenge that the ATM presented. I think anyone that is going to be in space for any length of time ought to have something that's going to be mentally challenging and enjoyable for them rather than just keeping up with a checklist."

Gibson and his crewmates, Gerald Carr and William Pogue, were the last humans to visit Skylab, but at the time they weren't certain if that would truly be the case.

Gibson: "We were the last American crew that we knew of that would get up to Skylab for several years to come. We also didn't know if the

Ed Gibson's Skylab Mission Portrait.

Russians were going to come up and inspect our space station. So we buttoned it up tight, but we didn't take any special precautions. In case the Russians were going to get up there and look around, we didn't put a welcome mat out, but we didn't try to hinder them either.

"The whole timeline that followed after we came back has surprised me; in fact, disappointed me—all of us for that matter.

"A basic space station should not be all that difficult. It was just a pressure shell with some electrical power, stabilization, environmental control, crew support and a couple of other systems. It should not have been all that difficult to recreate. We thought we ought to be able to have a first-class station up here within five years. Well, once the bureaucracy and the politicians got into it, it turned out to not be so easy.

"We finally have the International Space Station in orbit, which is a great facility, but it was way late in coming and almost was not approved. We are clearly disappointed that it took so long.

"Skylab could've been a good start. By building onto the Multiple Docking Adapter with modules as they became available, much like the ISS has done, we could have assembled a first-class space station a lot more cheaply and a lot earlier. Unfortunately, the Shuttle development was a little bit delayed and the reentry of the Skylab was earlier than we anticipated so we couldn't reach it in to prevent its re-entry.

Every astronaut believes that STEM education is important to not just the future development of space exploration, but also to having a thriving national economy.

Gibson: "I'm glad we still have great enthusiasm for space in our youth. In general, the road is pretty straightforward for kids today. First, figure out what you like. Is it medicine? Is it physics, geology, oceanography, material physics, astrophysics or piloting aircraft? Whatever it is, be as good as you possibly can at it. Most important, enjoy it thoroughly! If you really want to get into the astronaut program, use your high level of technical skills to enter. But remember, because the competition is stiff, you've got to really be good at it.

"For every person who applies to the astronaut program, there's probably another 20 to 80 who don't make it. It's not because they're not competent; they're just not quite as good as the people who did make it. You've really got to be at the top of your game. Take what you enjoy, and go do it with enthusiasm and excellence, If you don't make it, you still have a good profession you enjoy.

"Now the question is whether there is going to be a space program for them to get into?

"This is the first time in 50 years that we have not had a major operational program driving the development of technology. That is highly unfortunate. We've got some technology development, but it lacks focus, firm requirements and well defined programmatics that all relate to a clear inspirational vision. The development of human spaceflight, putting a space station into orbit, going to the moon and using reusable spacecraft were each driven by inspiring vision. That vision, drive and persistence is lacking today.

"When you look back at Apollo, you see that it required the development of many new technologies in order to get the job done. Sometimes we had systems developments going in parallel until the most reliable could be delineated. The development of these new technologies had a lot of technological spinoff,

which created a financial multiplication factor that increased the gross national product several times than what was invested by introducing these new technologies nationally and making us more competitive in the world marketplace.

"The early days of Apollo were rather heady. They returned many new technologies to our nation, commercially, as well as in terms of pride, spirit, and focus on education for the youth coming up. You just don't see real, concrete challenges for them anymore. It just isn't there.

"We need national and administration leadership that takes its eyes off its shoes and looks to the horizon and beyond for human exploration. Our Moon, Mars, and other bodies in our solar system should be specifically targeted with a clear, focused and logical overall plan. Addressing asteroids can be accommodated but only as a byproduct of these main objectives. No doubt America has put itself in a highly restrictive financial position. However, if we do not clearly lay out visionary programs that build on the Mercury, Gemini, Apollo, Skylab, Apollo-Soyuz and Shuttle programs, we will remain in the doldrums into which we have retreated. Progress and necessary support comes only from vision and drive, not timidity and withdrawal."

Looking into future exploration missions, Gibson has an opinion on what we should be doing now in order to eventual become an interstellar species.

Gibson: "To instill an overriding, long-term vision in our youth, general population and national leadership, we collectively have to create greater awareness of the bigger picture. When we got back and looked at what we had done – travelled 35 million miles in 84 days – we thought that we really had accomplished a lot. Then we got out the calculator and realized that it takes light just three minutes to go that same distance. Yet it takes light over four years just to reach our nearest star. So when it comes to REAL space travel, we've barely nudged the tip of our collective toe out the front door.

"I have no doubt that we will eventually travel out to other star systems. But that is many generations down the road. I can't predict how we are going to work around the immense distances and the need to accelerate up close to the speed of light, but eventually that will happen.

"In the shorter term, we've got a whole solar system out there to explore. We need to focus on specific visionary programs and develop the capabilities to successfully perform them. I would first go back to the Moon, and then on to Mars. Mars appears to present a good opportunity for finding some form of life. We've found water there and we might also find some evidence of past or even present life. Much of these early explorations can best be done unmanned, as we are doing now, but ultimately it's we who have to go there in person to see, feel and study this new turf up close.

"Then we should spread out to other bodies in our solar system. We're learning a great deal every day about other moons and planets. Again, the potential for life is one of the drawing cards. Also, the Hubble Space Telescope is a great observatory, but I'd like to see the James Webb Telescope in operation and even better ones in the longer term. Eventually we will be able to image the details of planets around other stars. And if we do see one, a blue planet with an oxygen atmosphere, the pull would be irresistible!

"We're discovering planets all the time. We're bound to find some planets that have a potential for life which could have matured like it has here on Earth. There are bound to be many planets that are in their stars' 'Goldilocks' zone; that is, where it is not too hot, not too cold and free of excessive radiation and gravity. New knowledge will always be a continuous draw.

"In fact, the more we learn, the more ignorant we realize we are. Recently we come to understand that what we thought was our total world is really at most five percent of the universe in which we are immersed. Dark matter and dark energy make up the remainder...unless there's more out there of which we are not yet aware.

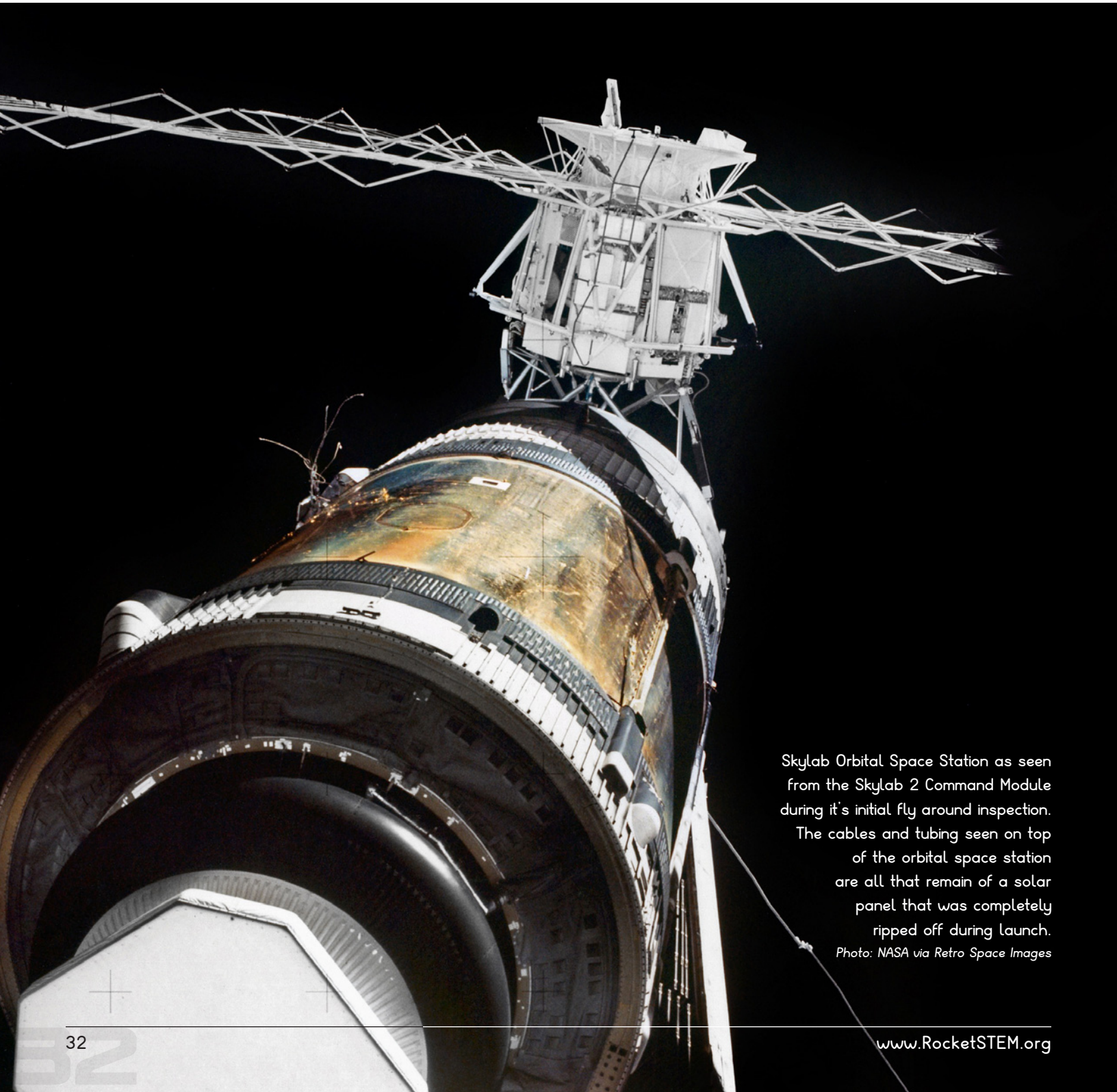
"There's a lot to do, a lot to learn and a lot to utilize. If we truly are a great nation, we will take our vision off our shoes and look to the horizon!"

Scientist–astronaut Ed Gibson has just egressed the Skylab EVA hatchway during the final Skylab Extravehicular Activity EVA which took place on February 3, 1974. *Photo: NASA*

Skylab: America's first space station

DISASTER

followed by **TRIUMPH**



Skylab Orbital Space Station as seen from the Skylab 2 Command Module during it's initial fly around inspection. The cables and tubing seen on top of the orbital space station are all that remain of a solar panel that was completely ripped off during launch.
Photo: NASA via Retro Space Images

Story by Ben Evans

The Skylab Space Station atop a Saturn V rocket is transported to Pad 39A in 1973.

Photo: NASA via Retro Space Images

The launch of any new spacecraft cannot be regarded as 'routine'; nor, indeed, can its inaugural checkout in orbit. The Skylab orbital workshop was an entirely new concept for the United States and a totally different spacecraft, larger, more spacious and in many ways far more complex, than any that had gone before.

Yet on the morning on 14 May 1973, a sense of optimism pervaded the Kennedy Space Center, as the last in a generation of Saturn V boosters was readied for its journey into space. Visually, it looked somewhat different to its lunar predecessors, for, instead of possessing three stages, it had only two, and in place of what would have been the final propulsive stage was the inert Skylab, capped-off by a bullet-like aerodynamic shroud.

With a near-perfect launch record, there was every expectation that the final Saturn V would perform admirably.

Launch at 1:30 p.m. EST seemed pleasing, with the vehicle going supersonic a minute after leaving the pad.

Then, telemetry in Mission Control showed the first indications that something was amiss. As Dave Shayler wrote in *Skylab: America's Space Station*, "The data, which went almost unnoticed, indicated a premature deployment of the protective micrometeoroid shield and the No. 2 workshop solar array." If it was not simply an instrumentation error, this signified very bad news for Skylab. If the micrometeoroid shield and one solar array had indeed deployed during the initial boost to orbit, they were as good as lost and the very future of the space station would hang by a thread.

The Saturn flew its pre-programmed ascent profile, with the second stage taking over when the S-IC first stage burned out. The five J-2 engines of the S-II second stage were automatically commanded to burn for a little longer than normal in order to compensate for the additional weight. Within ten minutes of leaving the Cape, the S-II shut down crisply and the next milestone was for the instrument unit atop the workshop to ready Skylab for orbital operations. The shroud separated and then, at 1:47 p.m., electric motors rotated the giant Apollo Telescope Mount (ATM) out 90 degrees. After it had locked itself into place, the ATM's windmill of solar arrays was deployed.

In the euphoria of those first few minutes, the mysterious piece of telemetry about the micrometeoroid shield and the workshop's own solar arrays almost went unnoticed.

Almost…

Within an hour of liftoff, Flight Director Don Puddy reported erratic signals. The main solar arrays should have been deployed when Skylab passed beyond the Madrid tracking station in Spain.

Tensions began to rise in Houston, as NASA managers listened for news from the tracking station, at Carnarvon in Western Australia.

The data was confusing. Controllers expected that their monitors would show the two large solar panels fully deployed and producing about 12.4 kW, some 60 percent of the required electrical load. It was with surprise and dismay, therefore, that the data indicated that power levels were much, much lower…at a mere 25 watts, in fact! The Carnarvon data suggested that the arrays had released for deployment, but had not fully extended, whilst temperature signals from the workshop implied that one array had either been torn away or had suffered severe structural failure, whilst the other had been released, but had not properly deployed.

The data from the next few orbits confirmed a failed micrometeoroid shield and a power outage owing to a solar array malfunction. These concerns were amplified later in the

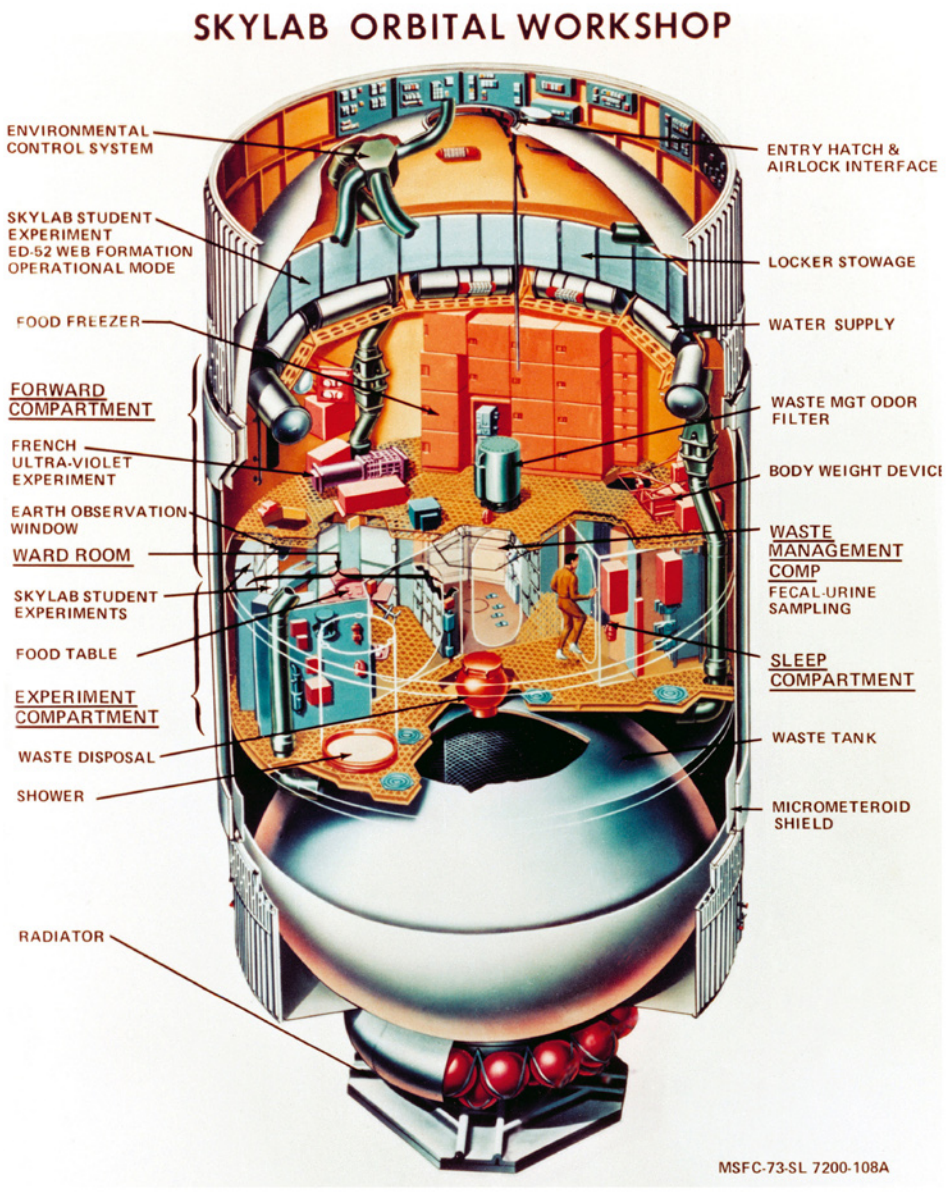
afternoon when telemetry pointed to an electrical short in the pyrotechnic relay needed to release the arrays.

In Mission Control, off-duty flight director Phil Shaffer set to work implementing a malfunction list to handle the myriad problems which were now flooding in from Skylab. "Puddy didn't have time for it," Shaffer related, in an interview quoted by David Hitt, Owen Garriott and Joe Kerwin in their book *Homesteading Space*. Within an hour or two of starting the list, Shaffer found that it already ran to nearly 50 mission-critical items! "At that point," he continued, "we stalled out on the post-insertion activation sequence…and stuff just kept failing and we could see it was beginning to get hot inside Skylab."

It was certain that Charles 'Pete' Conrad (Commander), Joe Kerwin (Science Pilot) and Paul Weitz (Pilot) would not be flying on 15 May and their launch was scrubbed within eight hours of Skylab reaching orbit. Based on the station's orbital geometry, launch opportunities occurred every five days and the mission was tentatively rescheduled for no earlier than 20 May. The astronauts flew back to Houston in their T-38 jets to develop a new flight plan, which called for a 17-day 'nominal' mission, then 'minimal activity' for a further 11 days in order to gather the medical data for a full four-week residency.

However, as this plan began to crystallise, the situation worsened. In order to produce electricity, Skylab needed to remain in a 'solar inertial attitude', with the Sun's rays perpendicular to the ATM solar panels, but this exposed the full length of the workshop to excessive overheating.

For a time, Mission Control limited the problem by pointing the front 'end' of the station directly at the Sun. This lowered temperatures... but also reduced power levels. The best compromise, it was found, was for Skylab to be pitched 'upwards', about 45 degrees, towards the Sun. This permitted just enough sunlight to illuminate the ATM arrays and



Artist's concept illustrating cutaway view of Skylab 1 Orbital Workshop (OWS).

Illustration: NASA via Retro Space Images

charge their batteries for the next period of orbital darkness, whilst also stabilising internal temperatures at around 42°C. Conversely, and somewhat ironically, temperatures in the airlock actually dropped precipitously and threatened to freeze heat exchangers and coolant loops by 18 May. Manoeuvres to warm the airlock succeeded, but at the expense of overheating the rest of the station. Therefore, the problem of maintaining this fine balance between temperature and power was extremely difficult.

Although it was clear that some sort of repair was critical, there was one saving grace: not all of Skylab's exterior required protection. In fact, covering the part of the workshop's exterior which directly faced the Sun would serve to bring temperatures within satisfactory limits and, furthermore, such a 'shade' would not need to be tied down or composed of strong or rigid material. In the hours after the accident, options for developing this material were exhaustively brainstormed throughout NASA and the proposals came thick and fast, ranging from spray paints, inflatable balloons and wallpapers to window curtains and extending metal panels.

At length, ten options were shortlisted for closer inspection, within

the guidelines that they must be lightweight, fit inside the cabin of the command module for transportation and were fairly straightforward to deploy. These options were ultimately winnowed down into three finalists: (1) the extension of a sunshade across the exposed hull of the workshop, erected by means of a long pole affixed to the ATM, (2) a sunshade deployed from the command module's hatch whilst station-keeping or (3) a sunshade deployed through Skylab's solar-facing scientific airlock.

Of these, Option 2 was the least technically complex, although its key obstacle was that Conrad, at the command module's controls, would be forced to hold position alongside the workshop, whilst his colleagues opened the hatch to put the sunshade in position.

The first option to erect such a shield would require additional EVA training. The third option would require the development of a shade which was capable of passing through a 20 cm^3 opening and then unfurling to cover an area of 7 m^2. It also meant that the scientific airlock would have to be sacrificed.

Conrad's crew had already done extensive EVA training on the ATM and felt that with the availability of suitable hand-holds and foot restraints, they could complete Option 1. Similarly, Option 3 was also 'doable', because they could at least work from within the pressurised – but very hot – confines of the workshop itself. At length, since no one knew if the scientific airlocks were cluttered with debris, Option 3 was ranked last. Johnson Space Center set to work on Option 2, and the Marshall Space Flight Center explored Option 1.

The Houston group envisaged a scenario in which an astronaut (probably Weitz) would perform a stand-up EVA (SEVA) in the open hatch of the command module and attach the sunshade in two places to the aft section of Skylab. Conrad would then manoeuvre his spacecraft to the forward end of the station, deploying the shade in the process and finally Weitz would make a third attachment at the ATM. This sunshade very quickly gained the moniker of 'SEVA sail' and its development was conducted under the auspices of Caldwell Johnson. For ten days, his staff worked on the shade, seamstresses stitched the orange material, parachute packers folded it for deployment, engineers attended to its various fasteners…and a steady stream of public tours gawped from a mezzanine gallery at what was going on.

Meanwhile, in Huntsville, the plan was to perform an EVA from the ATM itself. Their sunshade resembled a window blind and its design was completed on the evening of 15 May. Kerwin and the backup commander, Rusty Schweickart, flew to the Marshall Space Flight Center to participate in underwater EVA tests of both sunshades.

"One by one," recalled Schweickart of the exhaustive two-hour-plus session, "we eliminated things and by about midnight…we basically had the outlines of what we were going to do."

The Huntsville sunshade needed further work and the design which steadily evolved was a configuration of two 14 m long poles, which would be 'cantilevered' from the ATM. The poles would be assembled from a dozen smaller sections, allowing them to fit inside the command module, and a rope would run along their length, through a series of eyelets. The 7 x 6 m sunshade would be unfurled by tugging on the rope in a similar fashion to hoisting a ship's sail. This design came to be known as the 'twin-pole' sail.

An underwater test by Schweickart and Kerwin on 18 May showed that it would work, but also indicated that its pole sections might separate under stress. A locking nut was modified, the shade's weight was reduced and Teflon inserts were placed into the eyelets to reduce friction. Thereafter, the remainder of the work ran without a hitch.

Meanwhile, the option to deploy a sunshade from the scientific airlock had been revived and was steadily gaining momentum, with

SKYLAB:
The Flown and Unflown Missions

SKYLAB 1

The Skylab space station itself was launched into orbit on 14 May 1973. During ascent, one of the solar arrays was torn off, together with the micrometeoroid shield, and the second array was left jammed with debris. The launch of the first crew was delayed as NASA explored its options.

SKYLAB 2

The first crew to the space station consisted of Pete Conrad (Commander), Joe Kerwin (Science Pilot) and Paul Weitz (Pilot). They were launched into orbit on 25 May 1973 and spent 28 days at Skylab. During their mission, they performed a dangerous spacewalk to install a new sunshade and open the jammed solar array.

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a concept that came to be known as 'the parasol'. Tests showed that a combination of coiled springs and telescoping rods could fit inside a standard airlock experiment canister and could be deployed smoothly. Jack Kinzler, chief of the Johnson Space Center's technical services division, a close friend and neighbour of Conrad, developed the system by jury-rigging it from a parachute canopy and telescoping glass-fibre fishing rods in hub-mounted springs.

During a final review at the Kennedy Space Center on 19 May, Kinzler's parasol was accepted as the primary method and on the 24th the flight readiness review endorsed it. Having an astronaut standing in the hatch on an EVA was undesirable, since it would come at the end of a long, 22-hour day for the crew.

Equally, the twin-pole concept did not meet with the approval of the flight surgeons, who were aghast at the prospect of such a complex task so early in the mission, before the crew had properly acclimatised to weightlessness. However, Conrad felt that Kinzler's design was the simplest, safest and quickest method…and most likely to succeed.

Years later, Schweickart glowingly praised the efforts of the industrial and NASA workforces to save Skylab during those frantic days of May 1973. "I probably got a little bit of sleep," he recalled, "but most of the team who worked with me at Huntsville never slept for four days! It was totally round-the-clock and it was not just the resources of the centre; it was all of the resources of the whole aerospace industry."

Kerwin felt the same. "It was a great team," he reflected. "I look on Apollo 13 as the supreme test… for the Mission Control team. The Skylab problem was the supreme test for the engineering team. Both the contractors and the civil servants joined together, as one, and they figured out what the problem was."

Of course, the state of the arrays and the reason for the No. 2 array being unable to properly unfurl, could only be speculated until the arrival of Conrad's crew and the presence of three sets of eyes to physically see what was amiss. If debris was the problem, a repair method was acutely needed and engineers from the Marshall Space Flight Center set to work to adapt a cable cutter (not dissimilar to a heavy-duty tree lopper) and a universal tool with prongs for prying and pulling to open the jammed array.

Close up view of Skylab 2 Crewmember Joseph P. Kerwin performing an extravehicular activity (EVA), probably to repair the covering. *Photo: NASA via Retro Space Images*

On 19 May, the tools were successfully tested in Marshall's neutral buoyancy tank, with the Skylab mockup specially 'modified' with fragments of metal wire bundles, shards of bolts and other objects representative of a failed micrometeoroid shield. Conrad, Kerwin and Weitz took their turns underwater, evaluating the tools, practicing prying the debris away from the array and completing the whole procedure safely.

The tools had already left for the Kennedy Space Center when a certification review ruled that the pointed tips of the cutter were hazardous. New heads with blunt tips were quickly prepared and the change was made at the launch site. Now, however, the time for talking was over. Years later, in her book *Rocketman*, Nancy Conrad related that Pete's response to the seemingly endless testing was typically to the point: "Just get me up there!"

With their launch scheduled for the stroke of 9:00 a.m. EST, the morning of 25 May 1973 was particularly peaceful for the three astronauts.

"This was the least well-attended Apollo launch in history," Kerwin recalled, "because everybody had to go home and put the kids back in school. We arrived at the command module and looked inside and it was a sea of brown rope under the seats and under the brown

ropes were all these different umbrellas and parasols and sails and also the equipment that we had selected to try and free up the solar panel, which was a pretty eclectic collection of aluminium poles that could be connected together, and a Southwestern Bell Telephone Company tree-lopper with brown ropes to open and close the jaws. They handed us the checklist and said 'This is how to operate that stuff.' Some of it we'd seen, some of it we hadn't!"

The astronauts were unperturbed. Indeed, as their Saturn IB rocket cleared the Pad 39B tower and roared into the clear morning sky, Conrad declared that his crew could fix anything.

Launch was on time and kicked off an eight-hour orbital ballet to rendezvous with the crippled station. Conrad's call of "Tally-ho the Skylab!" as a steadily brightening star on the horizon drew closer masked, at first, the seriousness of what the astronauts were about to face.

The micrometeoroid shield was indeed gone, as was one of the two solar arrays, whilst the second was jammed by debris. As Weitz took pictures, Conrad performed a flyaround inspection, quickly ascertaining that the scientific airlock was not cluttered with debris, thereby making the deployment of the Houston parasol a realistic option, and asserting his conviction that a stand-up EVA with the cutter should be enough to free the jammed solar array.

The first order of business was a 'soft docking' at Skylab's forward port, engaging capture latches but not retracting the command module's docking probe to ensure a firm metallic embrace.

After a quick lunch, Conrad undocked from Skylab, depressurised the cabin and opened the side hatch. With Kerwin hanging onto his ankles for stability, Weitz tried to use the modified tree loppers and a kind of 'shepherd's crook' to free the jammed array. Unfortunately, despite his sterling efforts, it did not go well.

At first, Weitz positioned himself with his upper body poking through the hatch into the ethereal blackness of space. Kerwin passed him three sections to assemble a 4.5 m pole with the loppers on the end, whilst Conrad kept the spacecraft steady. "We had seen…that there was a piece of bolted L-sections from the thermal shield that had been wrapped up around the top of the solar wing," Weitz recalled, "and apparently the bolt heads were driven into the aluminium skin. We thought maybe we'd just break it loose, so we got down near the end of the solar array and I got a hold of it with the shepherd's crook. What we really hadn't thought about was – in heaving on it, trying to break the thing free – what I was doing, in effect, was pulling the command module in towards the workshop."

Weitz could quickly ascertain that he was physically moving Skylab, because its thrusters were spitting and spurting to maintain its attitude and correct the oscillations.

Meanwhile, Conrad had the un-

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SKYLAB 3

The second crew of Al Bean (Commander), Owen Garriott (Science Pilot) and Jack Lousma (Pilot) were launched on 28 July 1973 and spent 59 days aboard Skylab. Their mission was almost shortened when a problem was found with maneuvering thrusters on their command module, but turned into a remarkable success, despite episodes of space sickness which affected all three men.

SKYLAB RESCUE

When a problem was found with the Skylab 3 crew's spacecraft, a second craft was hurriedly prepared on the ground to rescue them if needed. Astronauts Vance Brand (Commander) and Don Lind (Pilot) were trained to fly a five-seater Apollo to dock with Skylab and bring Bean, Garriott and Lousma home. As circumstances transpired, the problem was steadily resolved and the rescue mission became unnecessary.

SKYLAB 4

The third and final crew of Jerry Carr (Commander), Ed Gibson (Science Pilot) and Bill Pogue (Pilot) were launched on 16 November 1973 and spent 84 days aboard Skylab. This was a world endurance record which lasted until 1978. Despite early incidents of space sickness and an overly ambitious schedule, which left the crew overworked

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enviable task of keeping the spacecraft as close as just 60 cm from the station, whilst at the same time trying to prevent the unwanted oscillations from causing a collision. His task was compounded by the fact that a third of his field of view was blocked by the command module's open hatch. "It made for some dicey times," Weitz recalled. As the two vehicles entered orbital darkness, he paused in his work, then resumed as they flew within range of the tracking station. The shepherd's crook was getting him nowhere and the torrent of four-letter words from all three members of the crew even prompted the capcom to advise them to modify their language; for they were on an 'open mike'.

The main problem, Conrad told the ground, was that a strip of metal had become wrapped across the solar array system during the separation of the micrometeoroid shield. Its metal bolts had tangled themselves in the array, thereby jamming it, and none of Weitz' actions to cut the strap, even with the loppers, were having any effect.

"Rather than cutting it across the short way, we were trying to cut along the long way," Weitz explained, "and just didn't have enough muscle with that thing, because it was six or eight feet out ahead of me and I was pulling on a line to try to do it."

The metal strap, ironically, was only a few centimetres wide, but it was riveted fast and Conrad knew they did not have a hope of breaking it using the tools in the command module. The attempt was called off and after 40 minutes or so the astronauts were instructed to close the hatch and re-dock with Skylab.

On their first attempt to dock, the probe did not engage with the drogue and no fewer than three further attempts were also fruitless. "Pete gave Weitz the controls," Nancy Conrad wrote, "depressurised the command module and opened the tunnel hatch. He and Joe dove head-first into the bank of circuits and gizmos, Pete cussing a blue streak as he sorted through wires, cutting and splicing like [an angry] Maytag repairman trying to get a dryer to work again."

A view of the repaired Skylab Space Station cluster in Earth orbit as photographed from the Skylab 4 Command and Service Modules (CSM) during the final fly-around by the CSM before returning home. The space station is contrasted against a cloud-covered Earth.

Photo: NASA via Retro Space Images

After an hour or so of re-routing and connecting wires, bypassing electrical relays for the capture latches on the tip of the probe, skinning knuckles and a handful of undesirable vocabulary, Conrad used the service module's thrusters to bring the two collars into direct contact, mechanically triggering the dozen capture latches.

They were at Skylab to stay.

Next morning, the crew opened the hatch into the multiple docking adaptor and Weitz was the first to enter Skylab. Pressure checks were quickly followed by air sampling to test for the presence of noxious toluene and carbon monoxide, both of which gave the workshop's atmosphere a clean bill of health.

At length, after several hours, the parasol was assembled and at 7:30 p.m. its rods were delicately threaded through the scientific airlock into vacuum. Next, the parasol itself emerged, folding out like a big patio umbrella.

However, all was not right: one

of its four folded arms did not swing out properly and Kerwin expressed dismay when he saw it had only deployed to cover two-thirds of its required area. "It's not laid out the way it's supposed to be," a dejected Conrad told Mission Control, as it became clear that the parasol was askew and somewhat crinkled.

Nevertheless, the ground team in Houston assured the astronauts that the wrinkles had probably set in during the coldness of the lengthy deployment, which took place during orbital 'night-time', and, as the material heated up in sunlight, it would spread out fully.

"I think the ground noticed the temperatures coming down," Weitz recalled. "Within an hour, they could tell." Indeed, overnight on 26/27 May, the temperature on the exterior of the workshop dropped by 55°C and its interior by 11°C. Eventually, the interior temperature stabilised at around 30°C. However, for the mission to survive and succeed, it was necessary to release the jammed array, and soon, and plans were set in motion for an EVA on 7 June.

Since the airlock was right in the middle of the Skylab cluster, with the hatch to the workshop at its aft end and a hatch to the station's multiple docking adaptor and the command module at its forward end, a fully-suited Weitz had to make sure that Conrad and Kerwin had all of their tools and tethers before he depressurised them. Weitz then retreated into the multiple docking adaptor.

The hatch was opened at 10:23 a.m., just before the workshop entered the dark portion of its orbit. Conrad assembled the tools – six 1.5 m rods were screwed together, the cable cutter was fitted and several metres of rope from the backup SEVA sail were tied to the cutter's pull rope – and then he and Kerwin moved into position alongside the antenna boom. The unlikely contraption thus enabled them to operate the cutter from 8-9 m away… just far enough from the airlock to the jammed array.

As Kerwin tried to close the cutters against the debris, it became apparent that he was 'slipping', because he was unable to establish a secure position for himself. For half an hour or more, with one hand steadying himself and the other trying to close the cutters, he struggled fruitlessly to complete the work. As his pulse rate began to climb, he decided on an alternative course of action and shortened his own tether, in an effort to steady himself against the edge of the workshop. It worked and after ten minutes or so he was able to tell ground controllers in Houston that the cutters were now securely fastened to the debris. Next, he pulled on the lanyard to operate them… and nothing happened.

Conrad made his way, hand-over-hand, along the length of the beam to see what was amiss, and precisely as he reached the cutter 'end', the jaws snapped shut, freeing some of the metal strap at 2:01 p.m. and hurling the commander into space. Fortunately, his tether restrained him from moving far from Skylab, and the jammed array now stood at 20-degrees-open.

The frozen damper, however, still resisted normal deployment and the holes on the solar array were smaller than on the ground model. The two men heaved, without success, until Conrad placed his feet on the frozen hinge, stooped to fit the tether over his shoulder and 'stood up'. Kerwin pulled on the tether and, this time, the solar array suddenly released and sprang into its full, 90-degrees-open position. Both astronauts were flung outwards by the catapult-like effect and arrested by their tethers.

Inside Skylab, the needles of the electricity meters dramatically jumped, signalling success. By the next day, 8 June, solar heating had fully extended the array and it was generating no less than 7 kW of much-needed power. From just 40 percent power, the station's output suddenly increased to around 70 percent. Against all the odds, Skylab's fortunes had been snatched from the gaping jaws of defeat. The mission was underway.

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to the point of exhaustion, the mission was enormously successful, performing observations of Comet Kohoutek and several spacewalks.

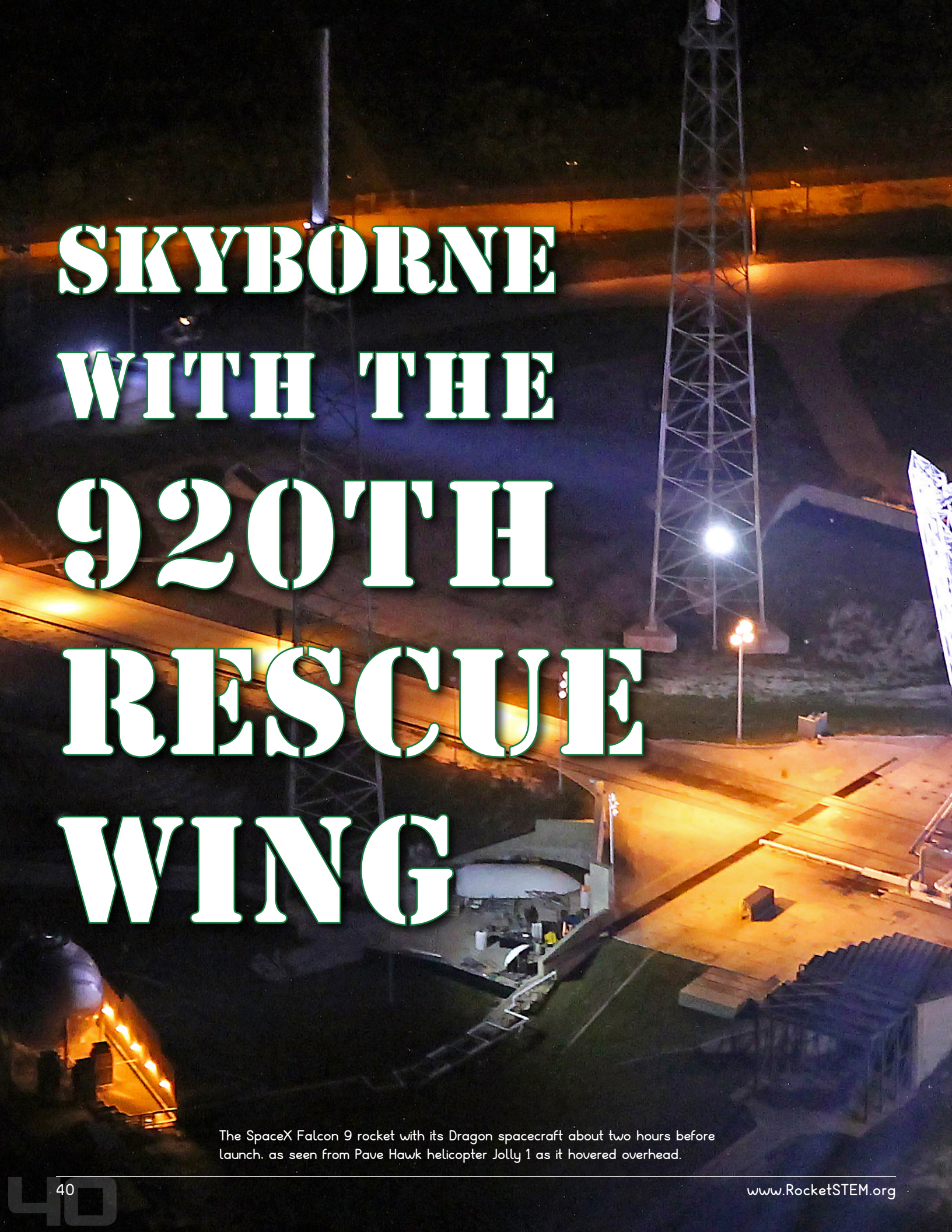
SKYLAB 5

At one stage, it was possible that a fourth crew of Vance Brand (Commander), Bill Lenoir (Science Pilot) and Don Lind (Pilot) may have flown a short, 21-day mission to finish up some final experiments aboard Skylab. However, when Skylab 4 was extended from 56 to 84 days, this mission became unnecessary.

STS-3

One of the early plans for the Shuttle was to visit and re-boost Skylab into a higher orbit. On the third Shuttle mission, astronauts Fred Haise (Commander) and Jack Lousma (Pilot) would have transported a system to dock with Skylab and save it from a fiery re-entry. It was hoped that the Shuttle might enable a new series of Skylab missions in the 1980s. However, solar activity caused Skylab to descend to Earth faster than expected, the Shuttle was delayed and the mission was cancelled. Skylab burned up in the atmosphere in July 1979.

SKYBORNE WITH THE 920TH RESCUE WING



The SpaceX Falcon 9 rocket with its Dragon spacecraft about two hours before launch, as seen from Pave Hawk helicopter Jolly 1 as it hovered overhead.

Anyone who has witnessed a Space Shuttle or rocket launch in person from Cape Canaveral, Florida has probably seen the Pave Hawk helicopters patrolling up and down the coast in the hours before launch. The airmen onboard serve a critical role for every launch - providing safety and security surveillance to the Eastern Launch Range. Simply put, if they do not secure the range, rockets do not launch.

The 920th Rescue Wing, based out of Patrick Air Force Base, serves as an Air Force Reserve Command combat-search-and-rescue unit. They are responsible for a variety of demanding missions, ready to deploy at a moments notice, and trained to perform some of the most highly specialized operations in the Air Force.

They were the primary rescue force serving as "guardians of the astronauts" for 50 years, providing contingency response for a variety of emergencies that could potentially come up during a Space Shuttle launch or landing. These airmen and their elite team of Pararescuemen, known as PJs, are among the most highly trained emergency trauma specialists in the U.S. military, capable of performing life-saving missions anywhere in the world, at any time.

In addition to combat search and rescue operations, the 920th also provides search and rescue support for civilians at sea who are lost or in distress, as well as providing worldwide humanitarian and disaster-relief operations supporting rescue efforts in the aftermath of disasters such as earthquakes, floods, and hurricanes. When a covert four-man Navy SEAL team was ambushed and surrounded in a Taliban counter attack high in the Hindu Kush mountains of Afghanistan in the summer of 2005, the 920th is who they called for rescue.

In the spring of 2012, I was invited by the 920th to fly along on a range-clearing mission to support the historic launch of the first SpaceX Dragon spacecraft to the International Space Station. The mission, known as COTS-2, was the first to see a commercial company deliver supplies to the orbiting outpost, which orbits some 250 miles above Earth. No photojournalist had ever flown with the 920th for any launch since they

Originally produced by Mike Killian for ARES Institute's Zero-G News. All photography by Mike Killian.

Seen through a pair of Air Force issued night-vision goggles. 920th Rescue Wing Airmen prepare to take to the skies to secure the Eastern Range in support of the SpaceX COTS-2 launch.

began supporting the U.S. Space Program in 1961, I was the first, and I was very humbled for the opportunity.

Although America's human spaceflight program is currently 100% dependent on Russia since the retirement of NASA's Space Shuttle program, the 920th's role supporting unmanned rocket launches from the Cape is still as active, and as important, as it has ever been.

HAWKS & FALCONS

Crews take to the skies in one of the most sophisticated helicopters in the world, the HH-60G Pave Hawk, a "Black Hawk on steroids" according to Captain Cathleen Snow, Chief of Public Affairs for the 920th Rescue Wing. They feature an upgraded communications and navigation suite that includes integrated inertial navigation/global positioning/Doppler navigation systems, and satellite communications. They are also equipped with an automatic flight control system, night vision, and a forward looking infrared system - known as color radar - that greatly enhances night low-level operations and allows them to fly in virtually any weather, day or night.

Many of the Pave Hawks flown by the 920th still have bullet holes from their tours in Afghanistan and Iraq, a sobering reminder of the reality of their jobs as combat-search-and-rescue airmen.

I arrived at Patrick AFB at 12:30 a.m. May 19 for our flight supporting the first launch attempt. After security checks, I proceeded to go meet the crew and conduct the standard pre-flight briefing. The briefing is incredibly thorough, nothing is missed, everything from contingency plans in case of an emergency, to radio frequencies, to the positions of both Pave Hawks at launch time is covered.

Both Pave Hawk crews were also brought up to speed on the launch itself and the details of the COTS-2 mission, and they were not shy about showing their excitement for a one-second launch window as opposed to a typical two- or three-hour launch window. Our Pave Hawk would patrol north of the launch site, call sign Jolly 1. The other (Jolly 2) would patrol to the south of the launch site.

Once everyone was briefed it was time to put on our flight gear and life support equipment. The building where we geared up, at first glance, resembles a locker room at any gym, except instead of football helmets and dirty socks there are night vision goggles, parachutes, flight helmets and headsets, inflatable military life preservers, and probably a few pairs of dirty socks. We geared up and made sure our headsets

worked properly, then walked to the flight line, where two of Patrick's 14 Pave Hawks were being prepared for our mission.

After talking with the crew and going over emergency scenarios, such as learning how to safely bail out of a Pave Hawk, the APUs started and the choppers came alive. Our pilot was Colonel Jeffrey "SKINNY" Macrander, who just so happens to be the Commander of the 920th Rescue Wing - responsible for the management and supervision of some 1,700 citizen airmen under his command. A veteran of Operations Allied Force, Northern Watch, Noble Eagle, Southern Watch and Operation Enduring Freedom, Colonel Macrander is a rated command pilot and has over 4,500 hours of flight time in five different military aircraft. He was also part of the crew who rescued ambushed Navy SEALS in the Afghan mountains in 2005.

"They usually like us to clear the box about two hours prior to launch. Since it is 2:00 a.m. we don't expect a whole lot of small boats out there, but we still get the commercial traffic that cruises back and forth," said Col. Macrander minutes before our flight. "The big boats are always up on a maritime frequency, so we have a special radio in the Pave Hawk to call and talk to the boats. We'll tell them to either speed up, change their course, or slow down so that they are not in the range for the launch window. We'll call the coordinates into the control office at the Cape and they will plot it, do some math, and let us know what the boaters need to do to stay out of the range. A lot of times the small boats are just fishing and not monitoring their radios, so sometimes we have to come down there and hover pretty close to get their attention and let them know with hand gestures to get on the radio."

I would find out later that evening just how close they get to those small fishing boats not paying attention to their radios. We even hovered within 200 feet of a boater who was sound asleep, using the noise from the rotors and flashing bright spotlights on his boat to wake him up. I can only imagine his reaction, waking up to an Air Force Pave Hawk circling him in the middle of the night.

As for the launch, it scrubbed 0.5 seconds before liftoff. A second launch attempt was scheduled for three days later. In the meantime I had a different assignment on the other side of the country, but was already looking forward to my flight for launch attempt number two.

DRAGON'S BREATH

I returned Monday night, May 21, at 10:30 p.m. to do it all over again, but this time with Lt. Colonel Rob Haston piloting our Pave Hawk. Lt. Colonel Haston has been supporting rocket launches for nearly twenty years, piloting Pave Hawks and clearing the range for nearly every launch since 1995 - including Space Shuttle launches and landings. He has witnessed three rockets explode, so he understands first hand the importance of the 920th's role in securing the Eastern Range for a launch.

Pave Hawk "Jolly 1" preparing to take to the skies to clear the Eastern Range in support of the SpaceX Falcon 9 COTS-2 launch.

"I liken supporting rocket launches to fishing. There are a lot of nuances to range clearing that I've experienced over the years," said Lt. Col. Haston. "You get to know the type of boats and generally where they are going. A lot of different skills are involved depending on the type of boats you are dealing with. You may be dealing with a 1,000-foot freighter with a non-English speaking captain, or a brand new boat owner in a sailboat." Lt. Col.

> "I liken supporting rocket launches to fishing. There are a lot of nuances to range clearing."
>
> – *Lt. Colonel Rob Haston*

Pre-flight briefing for our mission to clear the Eastern Range of unwanted guests for the SpaceX COTS-2 launch.

920th Rescue Wing Airmen ready a HH-60G Pave Hawk to fly our range-clearing mission.

The SpaceX Falcon 9 rocket ignites to send their Dragon spacecraft on the first commercial spaceflight to the International Space Station, as shot from a 920th Rescue Wing Pave Hawk helicopter – call sign Jolly 1.

Haston's unique experience supporting launches is, as he put it, "not the sort of thing you pick up in Air Force regulations," but rather tricks of the trade.

We went through the same routine as we did for the first launch attempt, but this time the crew gave me a pair of night-vision goggles so I could see what they see and shoot some photos to give viewers their perspective. The night vision goggles help amplify the available light from the Moon and stars by up to 5,000 times onto a green phosphorous screen; the human eye can distinguish more shades of green than any other color. There was no moon this night, and even 60 miles out over the ocean in the darkest black I have ever seen, the goggles illuminated everything, I could even see the ripple of waves on the ocean's surface.

We took to the skies two hours before launch, heading up the coast of Brevard County towards Cape Canaveral Air Force Station, where SpaceX Launch Complex 40 and their Falcon 9 rocket stood fully fueled. We hovered a short distance away from the rocket for a few minutes, allowing me to shoot some exclusive photos from our unique vantage point before heading out to sea to clear boat traffic off the range. Our orders were to clear an area about 20 miles wide and 60 miles long around the launch site.

"They (range control) want us to clear 8-10 miles away from the azimuth. With a small rocket like this, it's a small box, but because it's brand new we need to keep it pretty clear," said Lt. Col. Haston.

The night was fairly quiet, there was not much boat traffic getting in the way, but it was interesting to come within a couple hundred feet of a Carnival cruise ship and tell them to hurry up and get into Port Canaveral before the launch. I can only imagine the surprise people onboard must have felt when they saw, or heard, us circling overhead.

Lights go off in the Pave Hawk during night-ops. Small fluorescent tubes reference our emergency exits, and the cockpit controls and displays - as well as the LCD screens on our cameras and cell phones - were the only lights we had. The pitch black view 60 miles out over the Atlantic allowed the Milky Way to shine brightly in the sky, and the sound of our rotors with no visual of anything was very strange, even eerie.

At one point I lost all reference of direction and could not even see the camera gear I had strapped to me.

Eventually the lights of Florida's Space Coast began to shine, and the unmistakeable sight of xenon lights on the Falcon 9 rocket came back into view. Even from 30 miles out, on a dark moonless night, NASA's massive Vehicle Assembly Building stood out like a sore thumb - many of my friends and colleagues were on the roof to cover the historic launch.

We arrived at the shoreline north of Kennedy Space Center about 20 minutes before launch, at which point we headed south along the beach, over Apollo/Shuttle launch pads 39B and 39A before hovering one final time next to the Falcon 9 for some last minute photos. We then proceeded to fly over KSC, at which point Lt.

Col. Haston brought us over to the VAB, circling it from the back and bringing us within throwing distance of the rooftop and the press site. I could see some of the press corps flashing lights at us, their way of saying hello - we were close enough that I could see the light from the LCD screens on their cameras.

We positioned ourselves just north of the VAB and hovered with a great view of Falcon 9 out the left side of our Pave Hawk. We listened to the launch commentary on our headsets and watched in awe as the Falcon 9 roared to life under cover of darkness. The power of its nine Merlin engines turned night into day and the entire landscape of Kennedy Space Center lit up. The rocket and its Dragon spacecraft accelerated quickly through the atmosphere, vanishing as it climbed above the Pave Hawk's rotors and out of view, at which point Lt. Col. Haston tilted us up so I could get in a few more shots. We then circled to try and position ourselves for another view, but by that time the rocket was already gone, still visible, but already on the edge of space en route to the International Space Station.

Night vision displays green because the human eye can distinguish more shades of green than any other color.

With that, our mission was complete, and we headed south back to Patrick. As we approached Port Canaveral, the first stage of the Falcon 9 was already re-entering the Earth's atmosphere, shining as bright as a comet as it plunged back to Earth. Upon reaching the Port, Lt. Col. Haston decided to show me a little more of what the Pave Hawk could do, performing some maneuvers that most would describe as a roller coaster ride over Port Canaveral. I'm sure some of the folks on the ground wondered why a Pave Hawk was going crazy in the sky, but it sure was fun.

"Day launches are my preference as you encounter wildlife from the aircraft. You can see various fish, turtles and dolphins, and the occasional whale while flying over the wide open ocean," said Lt. Col. Haston. "But supporting any landmark launch, like this one, is always a great thing to be a part of."

Landing at Patrick was the end of my day, or night, depending on how you look at it. But for the crews I flew with, it was just the beginning, as they were getting ready to perform a search-and-rescue operation for a ship 1,200 miles off the coast of Florida in the area of Bermuda. Their motto, "These things we do, that others may live" is a way of life for the men and women of the 920th Rescue Wing, and I am honored to have flown with them, twice, to cover a launch which marked a pivotal turning point for America's space program.

For more information on the 920th Rescue Wing, visit their website: www.920rqw.afrc.af.mil or follow them on Facebook: www.facebook.com/920thRescueWing.

Shortly before "lights out" as we took to the skies over Florida's Space Coast to clear the Eastern Range for the SpaceX COTS-2 launch.

Ignition of the Falcon 9's nine Merlin engines as seen from aboard the Pave Hawk.

A 920th Rescue Wing Airmen, fully equipped with night-vision goggles, spies the surroundings only seconds before takeoff.








Yuri's Night: *The world space party*

Story by David Parmet and Brice Russ



Yuri's Night: Through the years. *Photos (from top, left to right): NASA, Kris Amundson, Rádio Zero (flickr.com), Chase Clark, Scott Ashkenaz, Morten Arstad, NASA, J.L. Pickering, Chase Clark, Rádio Zero (flickr.com), Michael Wright, Scott Beale, Loretta Hidalgo Whitesides, Ethan Hurdus, and Braden Kowitz.*

Human exploration of space began more than a half century ago with the launch of Vostok 1 on April 12, 1961. The small capsule carried cosmonaut Yuri Gagarin, the first human to leave the bonds of Earth and enter space. Exactly 20 years later, the United States began a new era in spaceflight with the inaugural launch of the Space Shuttle.

Twenty years after that, an annual celebration of our exploration of space began by connecting thousands of people around the world to celebrate past accomplishments and to inspire a new generation.

That event is Yuri's Night. Every year on April 12, Yuri's Night brings the excitement and promise of space travel closer to people of all ages and all nationalities.

What Is Yuri's Night?

Yuri's Night is a global celebration of humanity's past, present and future in space. Yuri's Night events combine space-themed partying with education and outreach. These can range from an all-night mix of techno and technology at a NASA Center, to a movie showing and stargazing at your local college, to a gathering of friends at a bar or backyard barbecue.

Yuri's Night brings together scientists, educators, artists, space fans, and everyday partygoers to use space as a catalyst for developing the next generation of explorers. Yuri's Night promotes space exploration and scientific discovery to people of all ages and backgrounds, and works to connect the world in a single celebration of humanity's greatest achievements.

In 2011, the 50th anniversary of human spaceflight, over 100,000 people attended 567 officially-recognized events in 75 countries on all seven continents, while tens of thousands more watched the 12-hour live Yuri's Night Global Webcast, and participated online in the virtual world of Second Life.

April 12, 2001: Launch of Yuri's Night

Yuri's Night was created by Loretta Hidalgo, George Whitesides, and Trish Garner in September 2000 to celebrate the upcoming 40th anniversary of Gagarin's flight. Seven months later they kicked off the inaugural Yuri's Night at the UN's Space Generation Advisory Council Conference in Graz, Austria. The World Space Party was celebrated at 64 events around the world.

The flagship event in Los Angeles brought together VIPs including pop singer (and space enthusiast) Lance Bass, scientists and engineers from JPL, and the Hollywood party crowd for an event that truly rocked the house. Melbourne had a posh affair with space cocktails; the Amundsen-Scott South Pole Station did a toast; Cape Town celebrated with a space wedding complete with a Shuttle cake; Vancouver, London, Leiden, Istanbul, Bröllin, and Dublin all had large dance parties; Boston put on a full day of events; and in Houston even the NASA brass showed up to get down.

Felipe Hernandez (or Astrolipe), a DJ/space architect from Chile, was interviewed by CNN en Español. Loretta was on the KNBC local news live in the studio,. Chris Welch was on BBC Radio, and George was on both NPR's Morning Edition and MTV's Mandy Moore Summer Special – where he was highlighted as a good guy for his efforts to bring the planet together to dance for space.

After the party, young people from the LA club scene told us it was the best party they had been to and thanked us for creating such an awesome space. Young engineers from JPL stopped and told us it was the most fun they had had out in a long time. We succeeded in doing what we had set out to do – bring together the people who really work for space with the people who think space is cool and want to be a part of it.

Yuri's Night today

Since that first event, Yuri's Night has continued to grow and become, not just a party, but a cultural touchstone for space fans around the world. Yuri's Night has been celebrated everywhere from Alabama to Australia, from Stockholm to Second Life, by crews at the Amundsen-Scott South Pole Station, and by astronauts on board the International Space Station. In 2008, over 10,000 people came to NASA Ames' Moffett Field to celebrate Yuri's Night with presentations by Tesla Motors, game designer Will Wright, and Grateful Dead bassist Phil Lesh at YN Bay Area.

With 112 events in 26 countries on five continents already scheduled, 2013 is shaping up to be one of the biggest years for Yuri's Night yet. Yuri's Night has rolled out a brand-new website and event management system, complete with a new Yuri's Night greeting from actor LeVar Burton (http://youtu.be/JlJc5YG24SU). This year, Yuri's Night is partnering with Science Cheerleader and SciStarter on Project MERCCURI, a microbial experiment which will send a sample from at least one Yuri's Night event to the ISS this fall.

For 2013, we have events registered around the world and more coming online every day. We have parties happening in Los Angeles, Houston, Paris, New Delhi, and too many other cities to list, so take a look and see if one's going on near you. If there isn't one listed yet, check back later - or start your own! There's plenty of time to organize an event at a local restaurant or school, or just throw a house party with your friends.

There are many ways to participate in Yuri's Night. Our new website (http://yurisnight.net) gives you the tools to find a party (http://yurisnight.net/find-a-party/) or organize one of your own (http://yurisnight.net/#/startparty).

If you can't organize or attend an event in your community, tune into the Yuri's Night edition of NASA's Third Rock Radio (http://thirdrockradio.rfcmedia.com/) on April 12, or join a Yuri's Night event on Second Life or another online network. We'll also be streaming video from parties around the world and posting photos and stories on Yuri's Night Live (http://live.yurisnight.net). Check our website for further details.

We'd love for you to join us as we help the world celebrate space in 2013. Rock the planet!

Gagarin's orbital flight secured place in history

On April 12, 1961, Yuri Gagarin became the first man in space. His mission lasted 108 minutes and he made one orbit around the globe. Upon his return to Earth, he was lauded as a hero and the Soviet Union enjoyed its continued position as the leading power in space.

But in the years and decades that followed, details of the flight revealed a very different picture of this historic Soviet accomplishment.

Despite its disadvantaged technological position to the United States, the launch of Sputnik in October, 1957 gave the U.S.S.R. the early lead in the space race.

Both the U.S. and the Soviet Union had begun taking steps towards manned spaceflight in 1959 – American astronauts and Soviet cosmonauts were selected and entered into training. Flight tests of launch vehicles and unmanned capsules progressed at steady rates in both countries.

The Soviets won the race to put a man in orbit first with Gagarin's Vostok 1 flight. It would be almost a year before NASA would put John Glenn into orbit around the Earth. Alan Shepard and Gus Grissom's 1961 suborbital flights paled in comparison.

According to reports published by the Soviet Union, a calm Gagarin met launch day with resolve. He and his backup pilot Gherman Titov suited up together before piling into the van that would take the men to the launch pad. Upon arrival, Gagarin faced the men gathered around the launch vehicle and addressed them as a group with a stirring farewell speech.

Russia's Yuri Gagarin, first man in space.

Vostok 1 launched on time at 9:22 a.m. Moscow time. The mission was like clockwork with Gagarin performing perfectly. The launch vehicle performed perfectly, enabling the capsule to achieve an optimal orbit. Orientation of the capsule and the all-important retrofire manoeuvres were on time. The capsule's sections separated cleanly – the instrument section and the descent vehicle were meant to come down separately to ensure the two pieces didn't collide upon landing. Gagarin landed safely inside his capsule at 10:55 a.m.

Immediately after the flight, the pilot's first comment was a formal mention to the Communist Party and specifically Nikita Khrushchev that the mission was successfully accomplished and that he landed safely at his preselected point without injury.

The elation of the Soviet people was evident in their press releases and public announcements. Great attention was drawn to the symbolism of the flight. Vostok translates as "east" or "dawn" and the flight was in the morning. It was said to be the true morning of a new era. Central to praise was Gagarin, the model Soviet and communist who would lead the world into the future.

These reports and press conferences, however, carried a strange tone. Speeches were filled with imagery highlighting the new era and praising Gagarin as its ambassador, but little was said about the actual flight. Reports were vague with repeating emphasis on Vostok's perfect landing.

In his post-mission address, Gagarin said very little of substance and his responses to questions were almost evasive. When asked at what point he'd been told he would be the first cosmonaut, he responded that he had been told "in good time."

Slowly, over the ensuing years, the perfect flight of Vostok 1 was unravelled to reveal an imperfect mission.

The morning of launch, Gagarin was indeed calm and in good spirits. His heart rate and breathing were both normal. His only complaint was boredom while waiting for launch. He requested some music to keep him company inside the capsule. The ground crew obliged and transmitted Russian love songs to him. Throughout the mission, his spirits remained high. Every time a

Authored by Amy Shira Teitel, an expanded version of this article appears on her Vintage Space blog. Photos are courtesy of Retro Space Images.

ground tracking station asked how he was doing, he would inquire as to their well being as well.

His speech on the launch pad, however, is a myth perpetuated by Soviet media. The snippets of stirring speeches heard over the radio were pieced together from a previous speech Gagarin had been told to read to an audience in Moscow months prior. The words came from an anonymous speechwriter.

Not everyone was calm, however. Chief Designer Sergei Korolev was so anxious the morning of the launch that he took tranquilizers to calm himself. His confidence in his own system had been badly shaken by the relatively high failure rate of the Korabl launch vehicle, particularly its third stage.

The flight itself was also far more problematic than the Soviet space program was willing to admit. The third stage didn't fail as catastrophically as Korolev feared, but it didn't perform perfectly either. Gagarin's orbit was higher than intended, making the already all-important reentry that much more important. With a high orbit, a missed retrofire would necessarily extend the mission beyond what the space program had trained for.

The higher-than-intended orbit turned out to be an innocuous problem. As the space program was wont to express, Gagarin landed safely and on target. It would turn out that this wasn't the case either. Not only did Gagarin not land on target, he didn't land inside the capsule. He ejected from his Vostok 1 and landed softly with his own parachute.

Gagarin's off-target landing was the result of the only major malfunction in the mission. Just after the retrofire burn during the early reentry and early descent, Vostok 1 began to roll. It got worse when the instrument unit failed to separate from the descent portion of the spacecraft. A series of cables failed to sever completely, keeping the two portions linked. They eventually separated ten minutes later when the heat from atmospheric reentry burned through them. Gagarin was spared a tumbling reentry.

Vostok's main chute was also late to deploy, forcing Gagarin to eject from the capsule early. He separated from his ejection seat and opened his own parachute. Vostok's chute did eventually open. The cosmonaut landed ten minutes after and miles away from his capsule in the Saratova, a region of Soviet Union not far from the border with Kazakhstan. He touched down on rural farmland, startling curious onlookers with his spacesuit and helmet.

Gagarin's true descent method, which makes it abundantly clear that Gagarin didn't land inside his capsule, wasn't revealed until 1971. The Soviet's deliberate veiling of this fact was done in an attempt to secure a formal record of the accomplishment. The Fédération Aéronautique Internationale, a French organization established in 1905 to maintain all records of accomplishments in aviation, had grown to include aeronautic and astronautic in the 1950s. Knowing the Soviets and the Americans intended to put a man in space, the FAI set the standard for what would constitute spaceflight. One of the conditions was that the pilot control the vehicle and land inside it.

The fact that Gagarin had orbited the Earth was certainly incontrovertible evidence of a flight in space, but the Soviet Union wanted to be sure their flight met the necessary guidelines.

The question of pilot control was another fabricated part of the story. Reports praised Gagarin for his perfect flight, but in fact he didn't pilot the Vostok capsule.

The capsule's controls were locked; only a pre-determined six-digit code could unlock to control when entered into a special onboard "logic clock". The pilot was only told the first three digits. If he lost contact with the ground or if he was in danger and needed to control the capsule to save his life and the mission, he could open a sealed envelope that contained the missing digits. Without forcibly unlocking the controls, the capsule would be entirely controlled either by its automatic systems of by the ground. Gagarin didn't open the sealed envelope.

In spite of its less sophisticated technologies and totalitarian system, the fact remains that the Soviet Union put a man into orbit first. The Soviets continued both their veiled ways and fast-paced accomplishments into the 1960s, only overtaken by the Americans midway through 1965.

Yuri Gagarin entered the history books as the first man to reach outer space. although his flight did not go as perfectly as was reported by the Russian media at the time.

NASA holding space settlement design contest

Design a space settlement! Space settlements are permanent communities in orbit, as opposed to a place to work for a few months and go home. Designing a space settlement involves physics, mathematics, space science, environmental science and many other disciplines.

The NASA Space Settlement Design Contest is for K-12 students throughout in the world. Individuals or teams may enter. Grade levels are judged separately, except for the grand prize.

Submissions must be received by March 15, 2014.

For more information about the NASA Space Settlement Design Contest, visit http://settlement.arc.nasa.gov/Contest/.

If you have any questions about the contest, please email Al Globus at aglobus@mail.arc.nasa.gov.

Lunar workshops open to educators

NASA's Lunar Reconnaissance Orbiter, or LRO, mission is sponsoring a pair of workshops for educators of students in grades 6-9. These workshops will focus on lunar science, exploration and how our understanding of the Moon is evolving with the new data from current and recent lunar missions.

The Lunar Reconnaissance Orbiter has allowed scientists to measure the coldest known place in the solar system, map the surface of the Moon in unprecedented detail and accuracy, find evidence of recent lunar geologic activity, characterize the radiation environment around the Moon and its potential effects on future lunar explorers and much, much more!

Workshop participants will learn about these and other recent discoveries, reinforce their understanding of lunar science concepts, gain tools to help address common student misconceptions about the Moon, interact with lunar scientists and engineers, work with LRO data and learn how to bring these data and information to their students using hands-on activities aligned with grades 6-9 National Science Education Standards and Benchmarks.

Workshops will take place: June 24-28 and July 8-12, 2013, at NASA's Goddard Space Flight Center in Greenbelt, Md. Workshop participants will have the opportunity to tour the LRO Mission Operation Center and the Goddard spacecraft testing facilities.

Each workshop will be limited to 25 participants. Interested educators are encouraged to apply early to secure a spot.

For more information and to register for the workshops, visit http://lunar.gsfc.nasa.gov/lwe/index.html.

Questions about these workshops should be directed to Katie Hessen at Katie.K.Hessen@nasa.gov.

Weeklong institute invites educators

NASA's Lunar Science Institute is hosting a weeklong institute for high school science educators. Participants will receive hands-on standards-aligned classroom resources that bridge the topics of Earth and the Moon, as well as a variety of science and engineering topics. Tours of scientific research facilities and interaction with lunar scientists will also take place during the institute.

The Unknown Moon Institute takes place June 24-28, 2013, in Laurel, Md. Registration is free, and applications are considered on a first-come, first-served basis.

For more information and to apply for the institute, visit http://www.lpi.usra.edu/education/workshops/unknownMoon/.

Questions about this opportunity should be directed to Christine Shupla at shupla@lpi.usra.edu.

SOFIA airborne program seeks ambassadors

NASA's Stratospheric Observatory For Infrared Astronomy, or SOFIA, is a 747SP aircraft carrying a 2.5 meter-diameter telescope. The SOFIA Airborne Astronomy Ambassadors Program is seeking educator teams of two to participate in an upcoming SOFIA flight. One of the team members must be a middle- or high-school educator. Applicants must be U.S. citizens or legal residents teaching in a U.S. school.

Applications are due May 3.

For more information and to apply online, visit http://www.seti.org/epo/SOFIA.

Questions about this opportunity should be directed to Pamela Harman at pharman@seti.org.

Student entries sought for mission mascot

NASA's Global Precipitation Measurement (GPM) mission has teamed up with the Japan Aerospace Exploration Agency to hold a design challenge for people around the world to develop an anime character to represent the GPM mission. GPM is a satellite mission that will use multiple satellites orbiting Earth to collect rain and snow data worldwide every three hours.

Participants should learn about the GPM mission and design their characters to represent the mission's objectives. The winning character will star in a comic series that will teach the public about GPM and precipitation science.

Participants must be at least 13 years old. Entries must be submitted by April 30, 2013. For more information, including instructions for submitting a character design, visit http://pmm.nasa.gov/education/anime.

Questions about this opportunity should be directed to GSFC-GPM@mail.nasa.gov.

Summer workshops open for students and educators

The Institute for Earth Science Research and Education, in collaboration with Queens College/ City University of New York, is seeking participants for summer professional development workshops in the third year of its Climate Science Research for Educators and Students project. This project seeks to improve student engagement in climate science by helping teachers and students develop authentic climate-related science research projects.

During summer 2013, two climate science workshops will take place in New York City. The first workshop will be held in late June. The workshop will focus on understanding sun/ Earth/atmosphere interactions and Earth's radiative balance. All participants will build instruments called pyranometers, which monitor solar radiation. A follow-up workshop will take place later in the summer. During the summer, participants will conduct their own research.

Applications are due May 1.

For more information, visit http://www.instesre.org/GCCE/GCCE-Home.htm.

Questions about this competition should be directed to David Brooks via email at brooksdr@drexel.edu.

For the classroom: Sizing up the clouds

Clouds, of course, are another form of water. But it's not easy to tell from the ground how much water is actually in the clouds above us. They may look very threatening but produce very little precipitation.

In the classroom activity called "Sizing Up the Clouds," the teacher sets up three simulated clouds representing three different cloud types.

Students use different methods to estimate precipitation contents of each cloud type. Each method is roughly analogous to methods actually used in weather forecasting.

Finally, the precipitation from each cloud is released, and the students will compare their estimates to what is actually experienced on the ground.

"Precipitation" in this activity is represented by colored chocolate candies, which may help to keep the students' attention!

Find the activity in PDF format at http://spaceplace.nasa.gov/classroom-activities/#cloudcontent.

Innovative LEARN program seeks STEM educators

The Long-term Engagement in Authentic Research at NASA, or LEARN, Project is seeking educators for an innovative program that provides onsite research and training opportunities with NASA scientists in the summer and guided research projects that continue on throughout the school year. Participants conduct their own research with help of a team of NASA scientists and share and integrate these projects into the classroom.

This summer, participants will complete two weeks of onsite work at NASA's Langley Research Center during the weeks of July 8-12 and July 15-19, 2013. Teachers will receive approximately 70 hours of professional development. Onsite work will be followed by continued research through 2014 via virtual research team meetings and data presentations. A stipend is offered.

This opportunity is open to science, technology, engineering and mathematics educators of grades 6-12. Earth science, physics, chemistry and mathematics teachers are encouraged to apply. Application is open to U.S. citizens only.

Applications are due April 22.

For more information and to register for the workshops, visit http://science-edu.larc.nasa.gov/LEARN/.

Questions about the workshops should be directed to Margaret Pippin at m.pippin@nasa.gov.

Student to attend, share experience of Soyuz launch

Abby Harrison recently received an invitation almost as rare as winning the Powerball lottery. ESA Astronaut Luca Parmitano has invited her as his guest to attend the Russian Soyuz-TMA-09M Launch to the ISS on May 28.

Harrison has long been a fan of space exploration and STEM education, having attended Space Shuttle launches, toured space agencies, and met many scientists, astronauts, engineers and physicists from around the world.

She writes about it all online at www.astronautabby.com as she strives to inspire kids to study and pursue STEM careers.

For the Soyuz launch, she'll be traveling first to Russia and spending four days there, before heading to Kazakhstan for the launch.

Harrison will be sharing the experience after she returns by leading a series of Skype classroom chats with students and teachers. Sign-up for a random drawing to have your school be selected for one of these classroom chats at http://astronautabby.com/signup/ before June 14.

She also has started a RocketHub fundraiser campaign to defer some of the costs of her long journey to Russia. You may contribute to the campaign at www.rockethub.com/projects/22119.

National Aeronautics and Space Administration

Public Safety Spinoffs

NASA has a long history of finding applications of space and aeronautics technologies that provide broad public benefits. The basis for the Agency's direction to do this can be directly traced to the National Aeronautics and Space Act that created NASA in 1958. Since that initial call to action, NASA's emphasis on safety has translated not just to its rocket launches and laboratory practices, but also to innovations that improve our everyday lives, protecting the public and making us safer by supporting emergency responders, providing for people in crisis situations, detecting biological and chemical threats, and enhancing national security efforts at home and abroad.

Apollo-Era Life Raft Saves Hundreds of Lives

During the Apollo Program, engineers at NASA designed and patented a hydrodynamically stabilized ballast system that would prevent a life raft from tipping in choppy seas and fierce winds. It has been commercialized and since been credited with saving over 400 lives.

Robots Save Soldiers' Lives Overseas

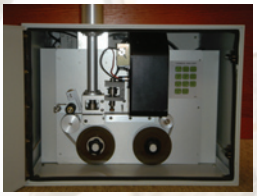
NASA efforts to help humans and robots to work together in remote environments led to the development of an improved reconnaissance robot deployed to war zones. Boasting a bevy of advanced capabilities, the newly-designed, remotely operated reconnaissance robot identifies improvised explosive devices (IEDs), allowing troops to maintain a safe distance.

Polymer Fabric Protects Firefighters, Military, and Civilians

NASA helped develop a line of polymer textiles for use in space suits and vehicles. Dubbed PBI, the heat and flame resistant fiber is now used in numerous firefighting, military, motor sports, and other applications.

Filtration System Provides Clean Drinking Water

A filtration system providing safe, affordable drinking water is the result of work done to create a simple wastewater remediation unit for the International Space Station. The commercial version of the technology yields clean water from the most challenging water sources, such as in underdeveloped regions where water may be heavily contaminated.



Anthrax Detector Protects Air Supplies

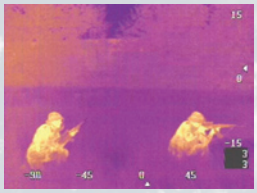
Designed originally as a bacterial spore detection system for Mars-bound spacecraft, the technology in the Anthrax Smoke Detector tests airborne particles for weaponized anthrax. The device is being used at airports, office buildings, and post offices worldwide.

Sensors Provide Early Warning of Biological Threats

Powerful NASA biosensor technology has been incorporated into a water analyzer that can alert organizations to potential biological hazards in water used for agriculture, food and beverages, showers, and at beaches and lakes—within hours instead of the days required by conventional laboratory methods.

Space Suit Technologies Protect Deep-Sea Divers

A company has incorporated NASA space suit innovations into deep-sea diving gear designed to protect divers who are called on to work in extreme and dangerous conditions caused by high pressure, chemical and biological warfare agents, and the toxic environments of shipwrecks and chemical spills.



Infrared Imaging Sharpens View in Critical Situations

NASA research into thermal imaging to help detect microgravity fires in space led to all-weather infrared imaging systems now being used in the United States and abroad to locate personnel stranded in emergency situations and to protect high-value facilities and operations—including soldiers in the battlefield.

Fire-Resistant Reinforcement Makes Steel Structures Sturdier

Fire-resistant material developed for the Apollo crew capsule heat shield now coats steel beams in high-rise buildings. The material—easy to apply, with no impact on architectural design—helps prevent infrastructures from collapsing prematurely in a fire, giving occupants more time to evacuate safely.

Rocket-fuel Device Neutralizes Land Mines

Surplus rocket fuel is used in a flare that can safely destroy land mines. The demining device is placed next to a land mine and ignited by a battery-triggered electric match. The flare burns a hole in the mine's case and ignites the explosive contents. Once the explosive material is burned away, the mine is no longer dangerous.

For more information about NASA spinoffs, please visit **spinoff.nasa.gov**.

NP-2009-10-619-HQ

Word Search

Look up, down, left, right, and even diagonally, for words from this month's issue.

K M E Q F T E U R O P A S F E A A S V B
X D B E M U C F R P L C S L A I I T K E
Q A V P K A Q U V E I O O P B L V F G A
R D P O S N M U R E N H C M I X C R O N
A V P C U O G E N I K R U K D R E O L S
L E L S M R A C U C O L U D M E I A N E
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Abby
Apollo
Astronaut
Bean
Black Hole
Carr
Clouds
Columbia
Conrad
Cosmonaut
Curiosity
Dragon
Earth
Endeavour
Europa
Exercise
Falcon
Gibson
Green Bank
Launch
Lockman
Mars
Moon
Musk
Nebula
Opportunity
Orion
Pogue
Radiation
Reentry
Rescue
Saturn
Science
Skylab
SOFIA
Sojourner
Solar
Soyuz
SpaceX
Spirit
Stars
STEM
Sun
Telescope
Yuri

Evolution of the space toilet

By Kaelan Jungmeyer

When Alan Shepard first went into space, he wet his pants. There was no toilet and that was his only option. Scientists put their heads together and created the modern diaper. Before this event, people used cloth diapers. The crews of the Apollo missions were a bit luckier, with diapers, but it still wasn't very pleasant. Then low and behold, the first space station had a toilet. Not a traditional toilet, but a toilet all the same. When engineers were working on the first space station they encountered an interesting problem. How would a toilet work? You can't have a traditional toilet that drains the bowl for obvious reasons. In zero gravity the water would float out of the bowl and create quite a mess. The engineers then had an idea. They would use suction. It used a fan driven suction system that transported the waste into a separate container. All waste that was recyclable was cleaned and reused. When in orbit the toilet was the first feature to be installed. In zero gravity the bodily system resets within two hours of being in space, so the toilet was mandatory. Several astronauts mentioned how beautiful it was to see their "waste" be jettisoned into space, since it would freeze instantly.

Toilet aboard Space Shuttle Challenger.

The first stage of the privately developed Antares rocket stands erect at newly constructed Launch Pad 0-A at NASA's Wallops Flight Facility. The maiden Antares test launch is scheduled for mid-April 2013. *Photo: Ken Kremer*

Antares blast off set for mid April

By Ken Kremer

NASA announced that the maiden flight of the private Antares rocket from Orbital Sciences Corp. is slated to soar to space between April 17 to 19 from the newly constructed seaside launch pad dubbed 0-A at the Mid-Atlantic Regional Spaceport at NASA's Wallops Flight Facility in Virginia.

The two stage Antares rocket serves as the launcher for the unmanned commercial Cygnus cargo resupply spacecraft, also developed by Orbital. Both Antares and Cygnus were constructed under NASA's Commercial Orbital Transportation Services (COTS) program to replace the ISS cargo upmass capability previously tasked to NASA's now retired Space Shuttles.

In mid- March 2013 I visited NASA Wallops for an up close personal tour of the impressive Antares first stage rocket erected at the launch complex following the successful 29 second hot fire engine test in late February that cleared the last hurdle to approve the Antares launch. Umbilical lines were still connected to the rocket.

The inaugural Antares test flight is called the A-One Test Launch Mission. It will validate the medium class rocket for later follow-on flights to the ISS. The first stage is powered by dual liquid fueled AJ26 first stage rocket engines that generate a combined total thrust of some 680,000 lbs. The upper stage features a Castor 30 solid rocket motor with thrust vectoring. Antares can loft payloads weighing over 5000 kg to LEO.

Orbital won a $1.9 Billion contract with NASA to launch at least eight resupply missions and deliver approximately 20,000 kilograms of supplies and equipment to the ISS; similar to the SpaceX Falcon 9/ Dragon system.

The April launch of Antares which mark the most powerful rocket ever to ascend near the major American East Coast population centers.

NASA's NuSTAR helps solve riddle of black hole spin

Two X-ray space observatories, NASA's Nuclear Spectroscopic Telescope Array (NuSTAR) and the European Space Agency's XMM-Newton, have teamed up to measure definitively, for the first time, the spin rate of a black hole with a mass two million times that of our Sun.

The supermassive black hole lies at the dust- and gas-filled heart of a galaxy called NGC 1365, and it is spinning almost as fast as Einstein's theory of gravity will allow. The findings, which appear in a new study in the journal *Nature*, resolve a long-standing debate about similar measurements in other black holes and will lead to a better understanding of how black holes and galaxies evolve.

"This is hugely important to the field of black hole science," said Lou Kaluzienski, a NuSTAR program scientist at NASA Headquarters in Washington, D.C.

The observations also are a powerful test of Einstein's theory of general relativity, which says gravity can bend space-time, the fabric that shapes our universe, and the light that travels through it.

"We can trace matter as it swirls into a black hole using X-rays emitted from regions very close to the black hole," said the coauthor of a new study, NuSTAR principal investigator Fiona Harrison of the California Institute of Technology in Pasadena. "The radiation we see is warped and distorted by the motions of particles and the black hole's incredibly strong gravity."

NuSTAR, an Explorer-class mission launched in June 2012, is designed to detect the highest-energy X-ray light in great detail. It complements telescopes that observe lower-energy X-ray light, such as XMM-Newton and NASA's Chandra X-ray Observatory. Scientists use these and other telescopes to estimate the rates at which black holes spin.

Until now, these measurements were not certain because clouds of gas could have been obscuring the black holes and confusing the results. With help from XMM-Newton, NuSTAR was able to see a broader range of X-ray energies and penetrate deeper into the region around the black hole. The new data demonstrate that X-rays are not being warped by the clouds, but by the tremendous gravity of the black hole. This proves that spin rates of supermassive black holes can be determined conclusively.

"If I could have added one instrument to XMM-Newton, it would have been a telescope like NuSTAR," said Norbert Schartel, XMM-Newton Project Scientist at the European Space Astronomy Center in Madrid. "The high-energy X-rays provided an essential missing puzzle piece for solving this problem."

Measuring the spin of a supermassive black hole is fundamental to understanding its past history and that of its host galaxy.

"These monsters, with masses from millions to billions of times that of the Sun, are formed as small seeds in the early universe and grow by swallowing stars and gas in their host galaxies, merging with other giant black holes when galaxies collide, or both," said the study's lead author, Guido Risaliti of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and the Italian National Institute for Astrophysics.

To learn more about NASA's NuSTAR mission, visit: http://www.nasa.gov/nustar.

To learn more about ESA's XMM-Newton mission, visit: http://go.nasa.gov/YUYpI6.

black hole

noun

a region of space having a gravitational field so intense that no matter or radiation can escape.

Image: NASA/JPL-Caltech

A window into Europa's ocean may be right at the surface

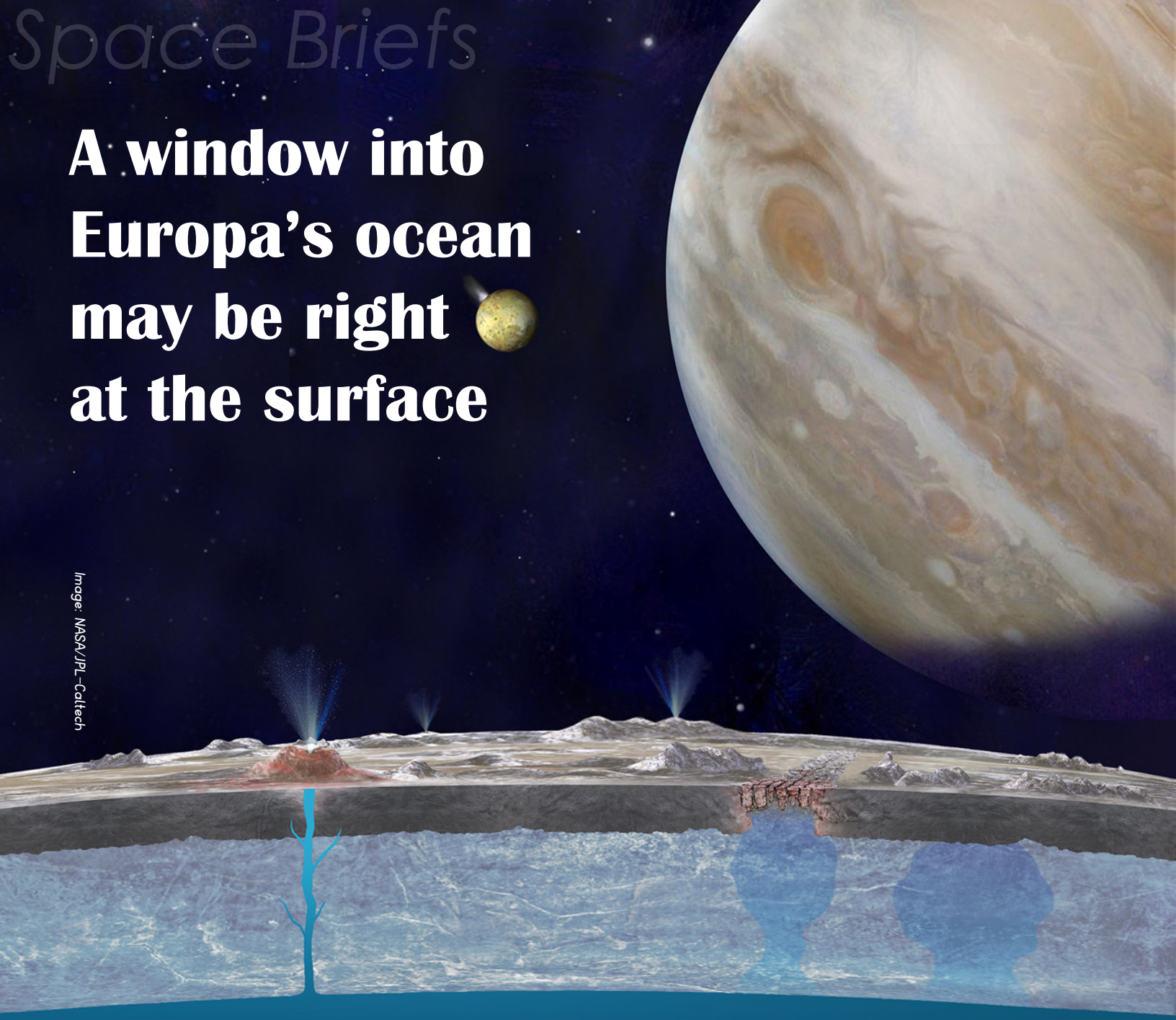


Image: NASA/JPL-Caltech

If you could lick the surface of Jupiter's icy moon Europa, you would actually be sampling a bit of the ocean beneath. Mike Brown, an astronomer at the California Institute of Technology, and Kevin Hand from NASA's Jet Propulsion Laboratory, have detailed the strongest evidence yet that salty water from the vast liquid ocean beneath Europa's frozen exterior actually makes its way to the surface.

The finding, based on some of the best data of its kind since NASA's Galileo mission (1989 to 2003) to study Jupiter and its moons, suggests there is a chemical exchange between the ocean and surface, making the ocean a richer chemical environment.

The exchange between the ocean and the surface, Brown said, "means that energy might be going into the ocean, which is important in terms of the possibilities for life there. It also means that if you'd like to know what's in the ocean, you can just go to the surface and scrape some off."

Europa's ocean is thought to cover the moon's whole globe and is about 60 miles (100 kilometers) thick under a thin ice shell. Since the days of NASA's Voyager and Galileo missions, scientists have debated the composition of Europa's surface. The authors believe the composition of Europa's ocean may closely resemble the salty ocean of Earth.

Europa is considered a premier target in the search for life beyond Earth. A NASA-funded study team led by JPL and the Johns Hopkins University Applied Physics Laboratory, has been working with the scientific community to identify options to explore Europa further.

"If we've learned anything about life on Earth, it's that where there's liquid water, there's generally life," Hand said. "And of course our ocean is a nice, salty ocean. Perhaps Europa's salty ocean is also a wonderful place for life."

Planck mission brings universe into sharp focus

The European Space Agency's Planck space mission has released the most accurate and detailed map ever made of the oldest light in the universe, revealing new information about its age, contents and origins.

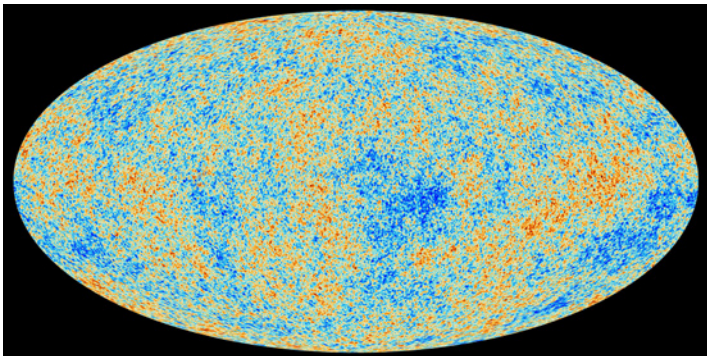
The map results suggest the universe is expanding more slowly than scientists thought, and is 13.8 billion years old, 100 million years older than previous estimates. The data also show there is less dark energy and more matter, both normal and dark matter, in the universe than previously known. Dark matter is an invisible substance that can only be seen through the effects of its gravity, while dark energy is pushing our universe apart.

"Astronomers worldwide have been on the edge of their seats waiting for this map," said Joan Centrella, Planck program scientist at NASA. "These measurements are profoundly important to many areas of science."

The map, based on the mission's first 15.5 months of all-sky observations, reveals tiny temperature fluctuations in the cosmic microwave background, ancient light that has traveled for billions of years from the very early universe to reach us. The patterns of light represent the seeds of galaxies and clusters of galaxies.

"As that ancient light travels to us, matter acts like an obstacle course getting in its way and changing the patterns slightly," said Charles Lawrence, the U.S. project scientist for Planck at NASA's Jet Propulsion Laboratory. "The Planck map reveals not only the very young universe, but also matter, including dark matter, everywhere in the universe."

The age, contents and other fundamental traits of our universe are described in a simple model developed by scientists, called the standard model of cosmology. These new data have allowed scientists to test and improve the accuracy of this model. At the same time, some curious features are observed that don't quite fit with the simple picture. For example, the model assumes the sky is the same everywhere, but the light patterns are asymmetrical, and there is a spot extending over a patch of sky that is larger than expected.



This map shows the oldest light in our universe, as detected with by the Planck mission. The ancient light, called the cosmic microwave background, was imprinted on the sky when the universe was 370,000 years old. It shows tiny temperature fluctuations that correspond to regions of slightly different densities, representing the seeds of the stars and galaxies of today.

Image: ESA and the Planck Collaboration

"On one hand, we have a simple model that fits our observations extremely well, but on the other hand, we see some strange features which force us to rethink some of our basic assumptions," said Jan Tauber, the European Space Agency's Planck project scientist based in the Netherlands. "This is the beginning of a new journey, and we expect our continued analysis of Planck data will help shed light on this conundrum."

Supercomputer helps mission expose ancient light

Like archeologists carefully digging for fossils, scientists with the Planck mission are sifting through cosmic clutter to find the most ancient light in the universe.

The task is more complex than excavating fossils because just about everything in our universe lies between us and the light. Complicating matters further is "noise" from the Planck detectors that must be taken into account. That's where a supercomputer helps out.

"So far, Planck has made about a trillion observations of a billion points on the sky," said Julian Borrill of the Lawrence Berkeley National Laboratory. "Understanding this sheer volume of data requires a state-of-the-art supercomputer."

Planck scientists have been accessing the supercomputers at the Department of Energy's National Energy Research Scientific Computing Center. This computer makes more than a quintillion calculations per second, placing it among the fastest in the world.

One of the most complex aspects of analyzing the Planck data involves the noise from its detectors. To detect the incredibly faint cosmic microwave background, these detectors are made of extremely sensitive materials. When the detectors pick up light from one part of the sky, they don't reset afterwards to a neutral state, but instead, they sort of buzz for a bit like the ringing of a bell. This buzzing affects observations made at the next part of the sky.

This noise must be understood, and corrected for, at each of the billion points observed repeatedly by Planck. The supercomputer runs simulations of how Planck would observe the entire sky under different conditions, allowing the team to identify and isolate the noise.

Another challenge is carefully teasing apart the signal of the relic radiation from the material lying in the foreground, but one that a supercomputer can handle.

Kepler discovers smallest planet yet

NASA's Kepler mission scientists have discovered a new planetary system that is home to the smallest planet yet found around a star similar to our sun.

The planets are located in a system called Kepler-37, about 210 light-years from Earth in the constellation Lyra. The smallest planet, Kepler-37b, is slightly larger than our moon, measuring about one-third the size of Earth. It is smaller than Mercury, which made its detection a challenge.

Astronomers think Kepler-37b does not have an atmosphere and cannot support life as we know it. The tiny planet almost certainly is rocky in composition. Kepler-37c, the closer neighboring planet, is slightly smaller than Venus, while Kepler-37d, the farther planet, is twice the size of Earth.

The first exoplanets found to orbit a normal star were giants. As technologies have advanced, smaller and smaller planets have been found, and Kepler has shown that even Earth-size exoplanets are common.

"Even Kepler can only detect such a tiny world around the brightest stars it observes," said Jack Lissauer, a planetary scientist at NASA's Ames Research Center in Moffett Field, Calif. "The fact we've discovered tiny Kepler-37b suggests such little planets are common, and more planetary wonders await as we continue to gather and analyze additional data."

Kepler-37's host star belongs to the same class as our Sun, although it is slightly cooler and smaller. All three planets orbit the star at less than the distance Mercury is to the sun, suggesting they are very hot, inhospitable worlds. Kepler-37b orbits every 13 days at less than one-third Mercury's distance from the sun. The estimated surface temperature of this smoldering planet, at more than 800 degrees Fahrenheit (700 degrees Kelvin), would be hot enough to melt the zinc in a penny. Kepler-37c and Kepler-37d, orbit every 21 days and 40 days, respectively.

The research team used data from NASA's Kepler space telescope, which simultaneously and continuously measures the brightness of more than 150,000 stars every 30 minutes. When a planet candidate transits, or passes, in front of the star from the spacecraft's vantage point, a percentage of light from the star is blocked. This causes a dip in the brightness of the starlight that reveals the transiting planet's size relative to its star.

For more information about the Kepler mission, visit: http://www.nasa.gov/kepler.

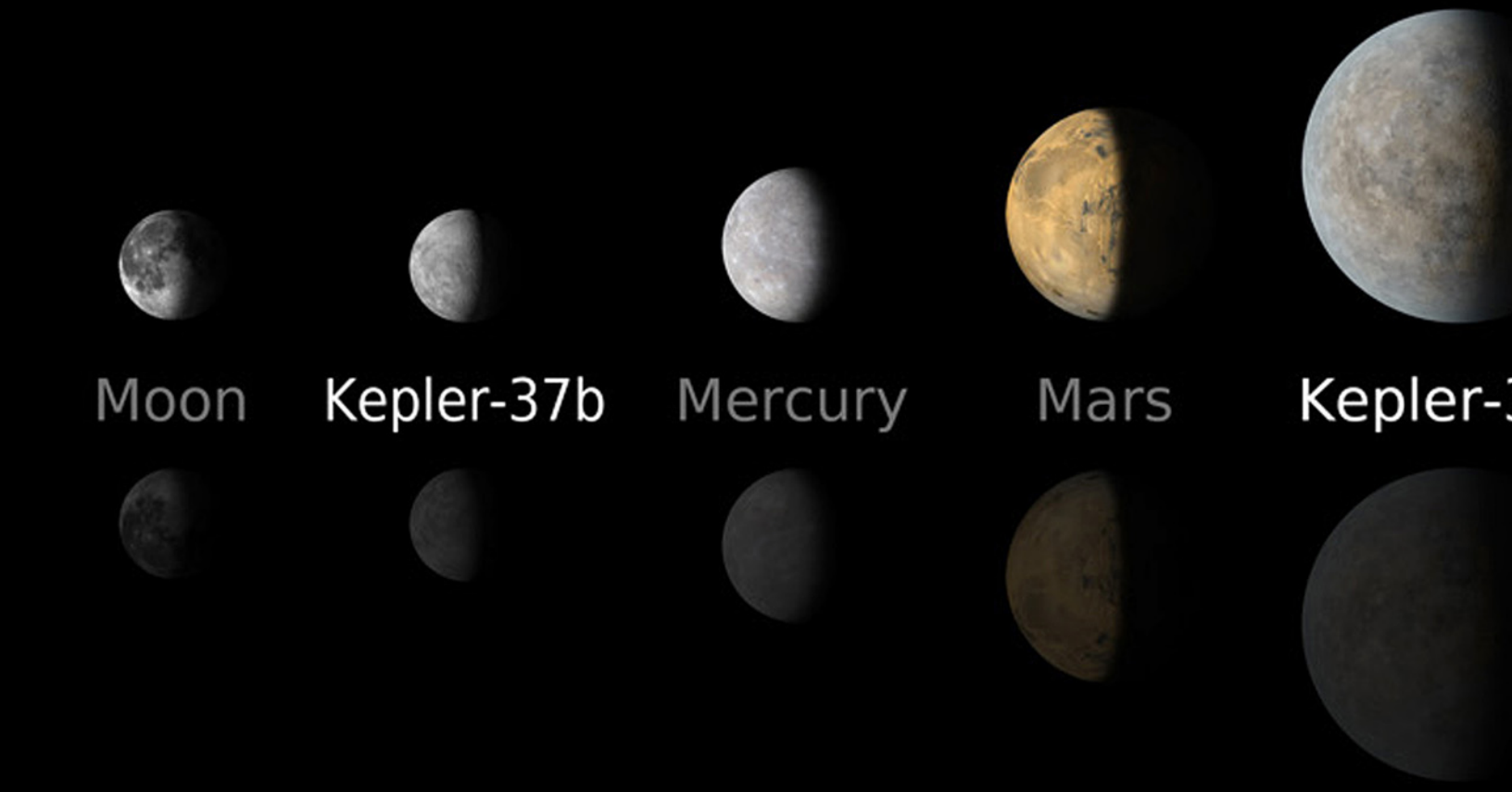


Image: NASA/Ames/JPL-Caltech

exoplanet

noun

a planet that orbits a star outside the solar system.

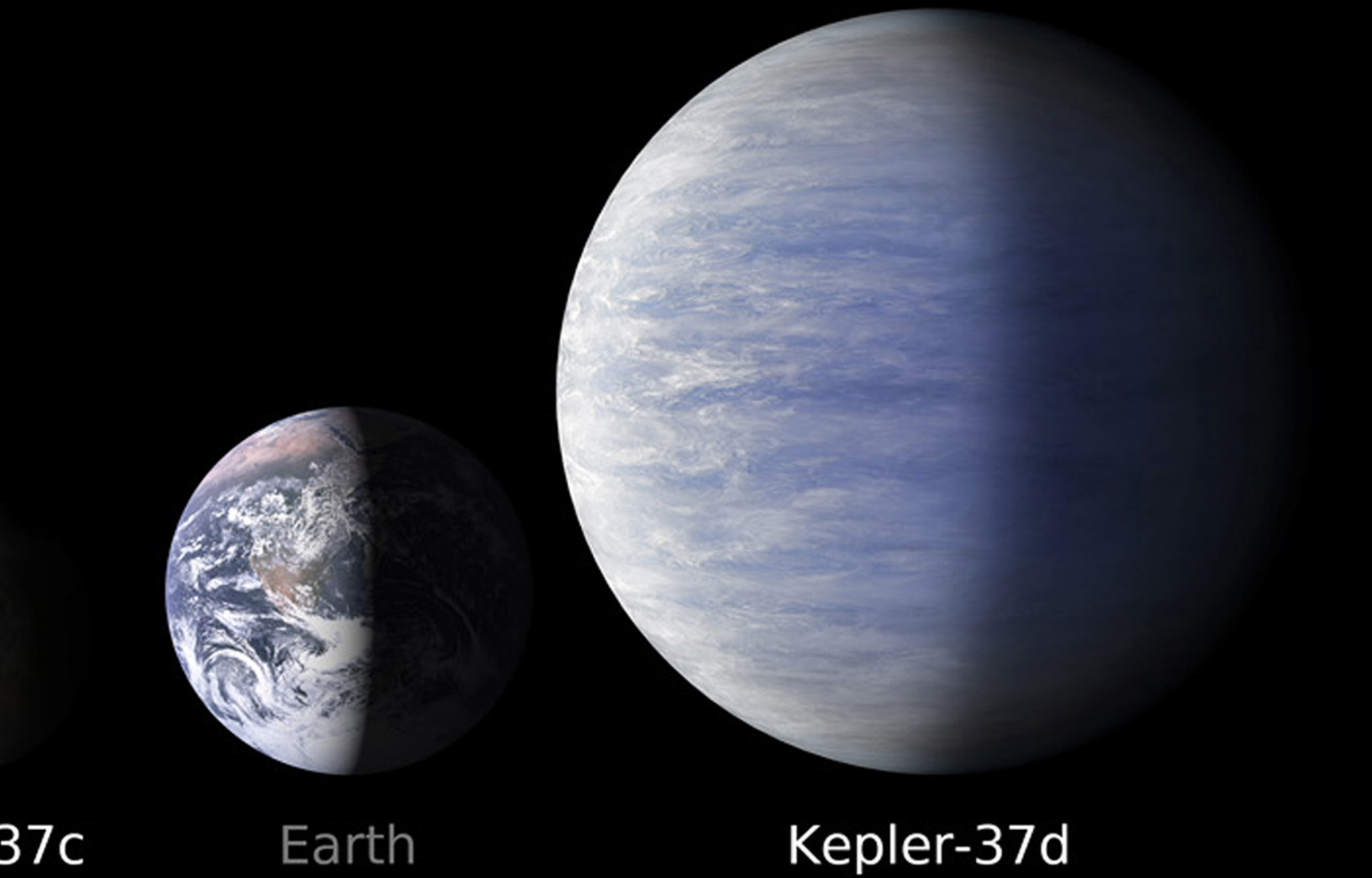


Photo: Brenden Clark

Photo: Brenden Clark

Photo: Walter Scriptunas II/Spaceflight Now

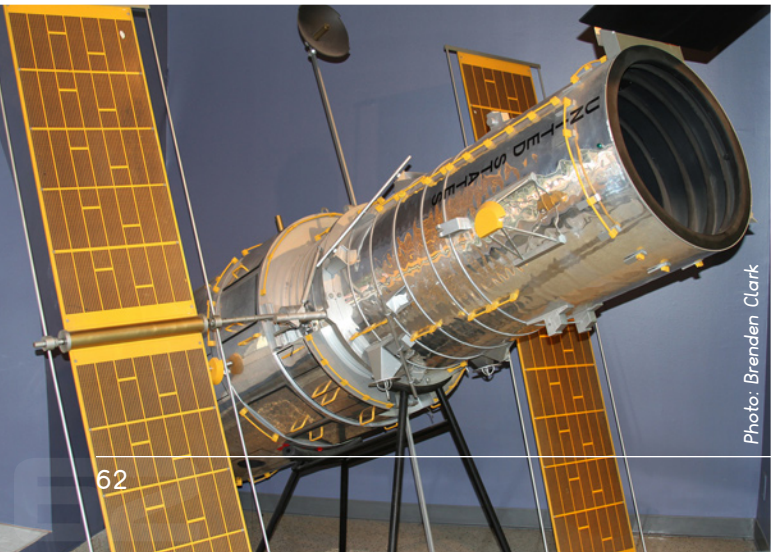


Photo: Brenden Clark

Photo: Brenden Clark

Endeavour to discover
at the California Science Center

By Brenden Clark

You're in Southern California, and the family wants to do something that is fun for all and affordable. Well Disneyland is out. Why not try the California Science Center? It might not have Mickey, Goofy or roller coasters, but does Disneyland have a real Space Shuttle? Oh, and did I mention - it's FREE!

Going on fifteen years now, the CSC is more popular than ever with the addition of Shuttle Endeavor. 600,000 children a year currently visit the facility with more than two million total visitors expected in 2013.

The CSC has something for everyone. Aquariums, games, puzzles, physical challenges, an IMAX Theater, historic artifacts of the space program, including real Apollo and Gemini Capsules, a full-scale engineering model of the massive Cassini-Huygens spacecraft, and of course, Endeavor. Oh and did I mention - it's FREE!

Photo: Walter Scriptunas II/Spaceflight Now

I had the pleasure of sitting down with Dr. Kenneth Phillips, the Curator for the Aerospace Science Programs at the CSC. We discussed everything from the future of propulsion systems for manned Mars missions to his favorite space movie… Forbidden Planet and The Day the Earth Stood Still. Which if you ever saw the original, not the Keanu Reeves remake, then you would know why it is so funny that Dr. Phillips memorized the phrase 'Klaatu barada nikto' as a kid. If the aliens ever did show up, he was prepared to save the world.

That brings us to the mission of the CSC. "Aspiring to stimulate curiosity and inspire science learning in everyone by creating fun and memorable experiences, because science is an indispensable tool for understanding our world."

That sounds great, but does it work? From seeing the hundreds of children having a great time the day I was there, I'd say - definitely. As Dr. Phillips said "What science centers are good at, the kinds of experiences we provide, if we are clever about it, are far more than just entertaining. They open doors for people. Not only in terms of stuff you will see and think about. They will open doors for them in terms of what they themselves can actually do."

He hit on a key to the future of science education: making science accessible and cool for children. We all know that science in the American school system is hurting. A science center is not a substitute for what needs to be taught in a classroom, but it is a stimulant that can help children want to learn.

"We've got to reach children early. Create experiences that they find memorable and they can succeed at," said Dr. Phillips. The key word being success. That is a theme that kept coming up in our conversation as well as around the center when I would see children trying to solve challenges or understand principles that an exhibit was demonstrating. The key is kids need to be able to succeed.

Too often we make it feel like advanced sciences are too hard, too out of reach for the everyday person, but the fact is, they aren't. Science takes work to learn. But so does football. So does art or music.

"Everybody in society has to be on the same page. We need to assure them that they can succeed and not take excuses for not succeeding," said Dr. Phillips. If we replaced "in society" with "on this team," you might think it was Phil Jackson giving a locker-room speech.

So what else does the CSC have planned for the future? Currently they are focusing on building the new facility that will house Shuttle Endeavor in a vertical position. They are trying to simulate the launch platform environment. It will be an astonishing display once finished. Right now Endeavour is housed in a hanger that barely fits her massive size. The hangar feels cramped, confined, but that loss is our gain as patrons can walk under her and get closer than most ever thought they could to a real Shuttle.

But Endevour needs to be free, and in a few years she will be. There are ways you can help. This is an expensive endeavor, forgive the pun, and they could

Photo: Walter Scriptunas II/Spaceflight Now

Photo: Walter Scriptunas II/Spaceflight Now

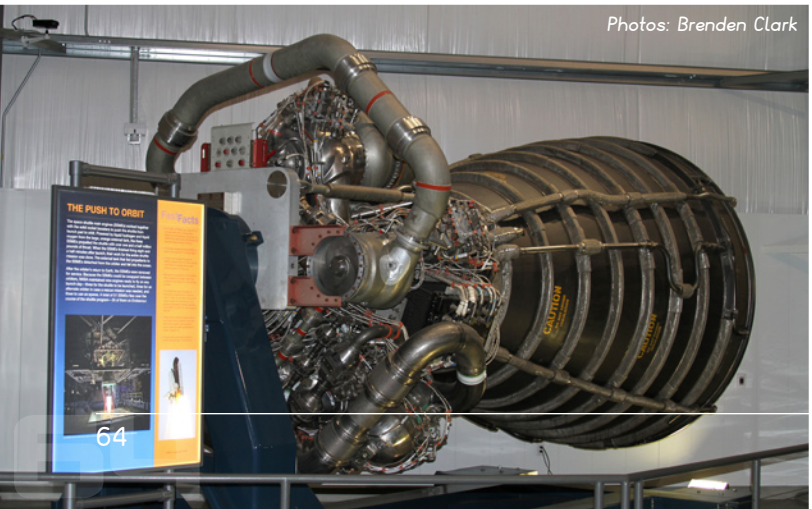
use your help. There is the Sponsor a Shuttle Tile Program. You can have your name displayed on a shuttle tile. Or you could donate to EndeavourLA. Or do something as simple as becoming a member of the CSC. Becoming a member gets you free IMAX tickets, free parking, High-Wire bike rides, wall cliff climbs as well as much more. All things that are more fun than Disneyland, and still cheaper.

Hey kids, if you want to make your parents happy, save them some money. A trip to Disneyland for the day, for a family of four - $334 just to get into the park. And it's an additional $152 if you want to go to California Adventure on the same day, for which no one has the stamina. Not even kids.

Science is an indispensable tool for understanding our world.

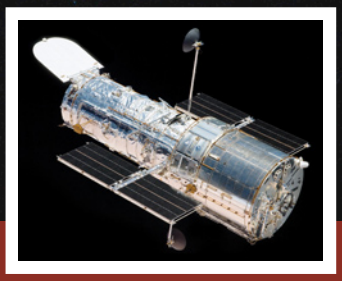
The California Science Center, for a family of four - $0.00. And if you want a second location, walk down the sidewalk about a hundred feet and you are at the Natural History Museum for half of what it would cost for a single ticket to get into Disneyland. What kid doesn't like dinosaurs? No kid I want to ever meet.

So you can go to Disneyland and spend a lot more money, learn nothing, and enjoy the two hour drive home after a long day, or you can visit downtown LA, spend practically nothing, learn while having fun and possibly be inspired by the world of science. No one ever changed the world by riding through the Haunted Mansion.



Photos: Brenden Clark

Image: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)



Hubble images a 'Rose of Galaxies'

In celebration of the anniversary of the Hubble Space Telescope's 1990 deployment into space, astronomers at the Space Telescope Science Institute in Baltimore, Md., pointed Hubble's eye to an especially photogenic group of interacting galaxies called Arp 273. The larger of the spiral galaxies, known as UGC 1810, has a disk that is tidally distorted into a rose-like shape by the gravitational tidal pull of the companion galaxy below it, known as UGC 1813. A swath of blue jewels across the top is the combined light from clusters of intensely bright and hot young blue stars. These massive stars glow fiercely in ultraviolet light. The smaller, nearly edge-on companion shows distinct signs of intense star formation at its nucleus, perhaps triggered by the encounter with the companion galaxy. A series of uncommon spiral patterns in the large galaxy is a tell-tale sign of interaction. The large, outer arm appears partially as a ring, a feature seen when interacting galaxies actually pass through one another.

Arp 273 lies in the constellation Andromeda and is roughly 300 million light-years away from Earth. The tenuous tidal bridge of material between the two galaxies are separated by tens of thousands of light-years.

Photo: NASA via Retro Space Images

April 12, 1981: Space Shuttle Columbia launched this day from the LC-39A pad at Kennedy Space Center in Florida. The STS-1 mission lasted just two days, circling the Earth 37 times, before landing at Edwards Air Force Base in California. Columbia carried a crew of two – mission commander John W. Young and pilot Robert L. Crippen. It was the first American manned space flight since the Apollo-Soyuz Test Project in July of 1975, and also marked the only time a maiden test flight of a new U.S. spacecraft system carried a human crew.