# RocketSTEM

Vol. 2 • No. 2 • March 2014 • Issue 6

Neil deGrasse Tyson, answers our questions about the 'Cosmos'

Spitzer turns 10: Gets a new life

An engineer's work: Boeing's V-22 Osprey

Bigelow envisions a future of inflatable space habitats

And much more inside...

Photo: Mike Killian

Photo: Mike Killian

# NASA launches third generation communications satellite

NASA's Tracking and Data Relay Satellite L (TDRS-L), the 12th spacecraft in the agency's TDRS Project, is safely in orbit after launching January 23 aboard a United Launch Alliance Atlas V rocket from Cape Canaveral Air Force Station in Florida.

Ground controllers report the satellite – part of a network providing high-data-rate communications to the International Space Station, Hubble Space Telescope, launch vehicles and a host of other spacecraft – is in good health at the start of a three-month checkout by its manufacturer, Boeing Space and Intelligence Systems of El Segundo, Calif.

"TDRS-L and the entire TDRS fleet provide a vital service to America's space program by supporting missions that range from Earth-observation to deep space discoveries," said NASA Administrator Charles Bolden.

The mission of the TDRS Project, established in 1973, is to support NASA's space communications network. This network provides high data-rate communications.

The TDRS fleet began operating during the space shuttle era with the launch of TDRS-1 in 1983. Of the 11 TDRS spacecraft placed in service to date, eight still are operational.

TDRS-M, the next spacecraft in this series, is on track to be ready for launch in late 2015.

# Contents



## Also Inside:



*Staring at the stars is the theme of this issue. Both above us in the sky, and in Hollywood, as we take you inside the production of the new "Cosmos: A Spacetime Odyssey." We think it is a show worth watching.*

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RocketSTEM • March 2014
Vol. 2 No. 2 Issue 6 (ISSN: 2326-0661)




RocketSTEM Media Foundation, Inc.
P.O. Box 304409
Pensacola, Florida 32507

email: ***info@rocketstem.org***


**On the Cover:** *Neil deGrasse Tyson is hosting "Cosmos: A Spacetime Odyssey.* *Image: Patrick Eccelsine/FOX*

*Starting in astronomy*

# beginner's guide to stargazing

By Mike Barrett

# David Hearn takes outreach to new level with observatory

Public Outreach is an oft used and abused term nowadays, but I find it the wrong label for astronomy. In Astronomy we are reaching out for the stars! What is really meant in this context is knowledge sharing and encouraging people to raise their eyes to the stars. I found it somewhat depressing that a survey published this week showed 1 in 4 Americans were unaware that the Earth orbited the Sun. This shows that there is a real need to get the message out, not only about Astronomy, but basic STEM as well.

Astronomers in general are a very approachable bunch of people almost always ready and willing to share their thoughts knowledge and more importantly their telescopes. This can be quite formal at pre-arranged open nights such as the Dark Sky Festival in Harmony, Florida, Astronomy Club open days, or casual visits to planetariums etc. In the UK we have a special week where the BBC encourage interest in space and astronomy with Stargazing Live events staged across the country. Most astronomy clubs hold open days when newcomers or people just generally interested in having a look through a telescope can come along and take part. Most clubs will be happy to accommodate visits to their dark site events, just look up your local club on the Internet and get in touch.

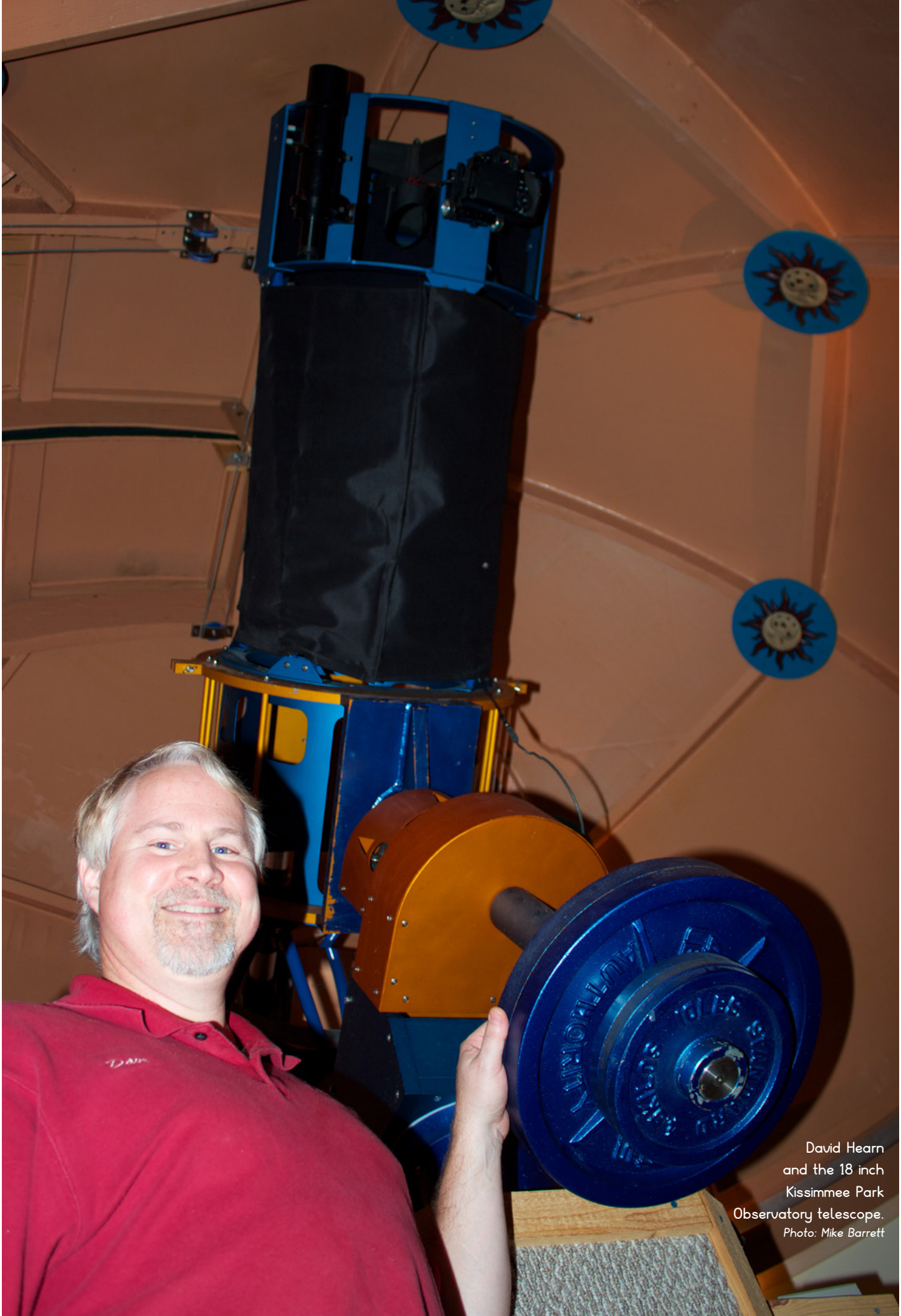
The Milky Way rises over the Kissimmee Park Observatory

*Photo: David Hearn*

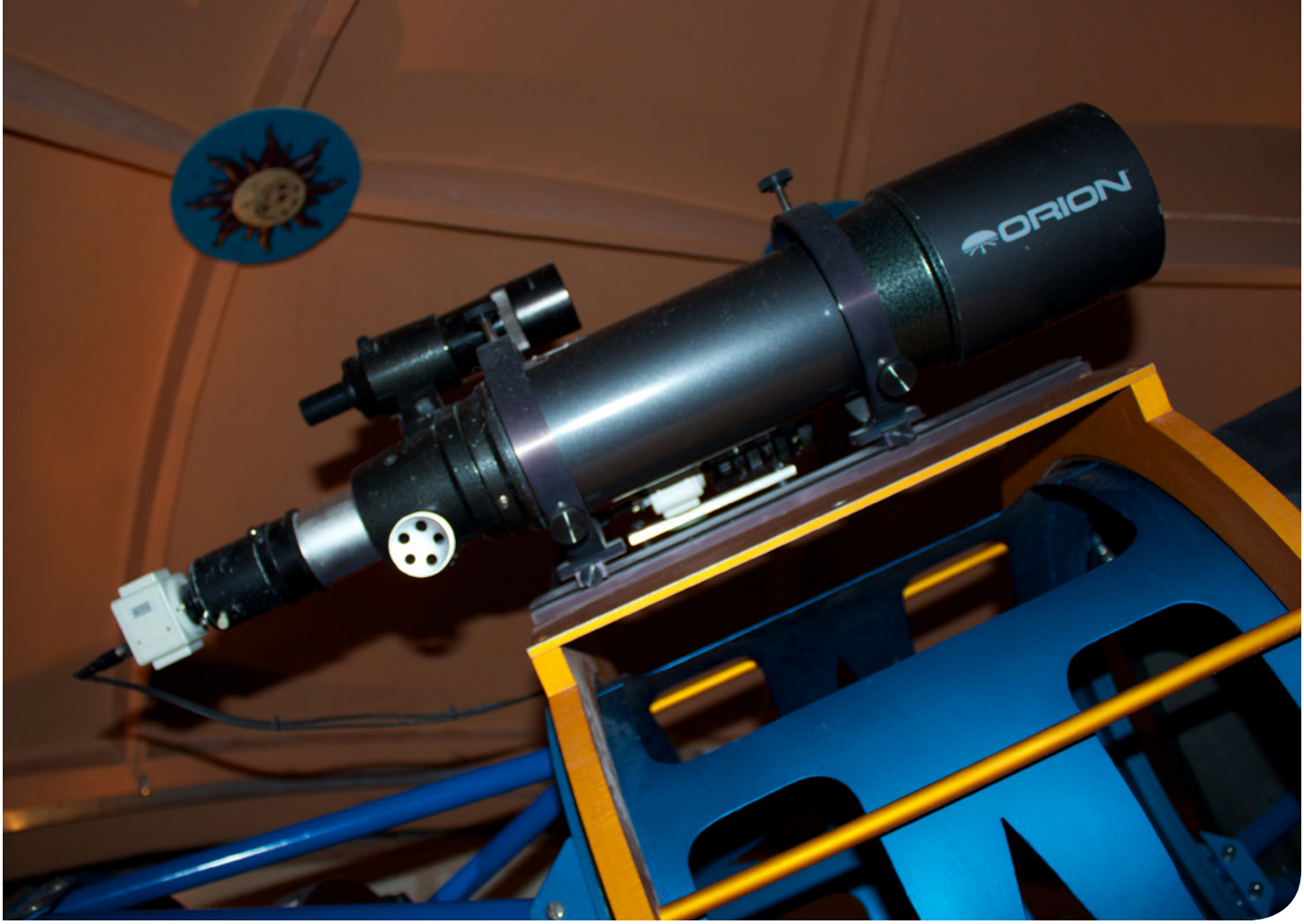
Another form of outreach involves planetariums. These can either be static such as found in local museums or transportable ones like the blow up StarDome run by our very own RocketSTEM contributor Andy Green in the UK. These bring the Universe into cities and classrooms to provide a realistic model of the night skies without having to dodge the clouds or other adverse weather conditions.

However the most selfless form of outreach I would describe as Private Outreach. There are a number of astronomers who have private observatories and open them up to the general public. Foremost among these was the late Sir Patrick Moore in the UK who was a great promoter of popular astronomy, providing maps of the Moon to NASA for the Apollo Moon Landings that were created from observations made in his backyard. I am going to focus on a relatively recent example: The Kissimmee Park Observatory on the banks of Lake Tohopekaliga in Florida. The KPO was designed and built by David Hearn who is, of course, a big astronomy fanatic.

I met David at the Harmony Dark Sky Festival back in 2013 shortly after the completion of his observatory. It was here that I learnt that once fully up and running he would be holding regular (and irregular) open



David Hearn and the 18 inch Kissimmee Park Observatory telescope.
*Photo: Mike Barrett*




Finder scopes piggy-backed on the main telescope. *Photo: Mike Barrett*

nights when people could come over and learn about our night skies. These are held around each new moon, weather permitting, or by appointment. I thought it would be interesting to describe the observatory to get an insight as to the workings of a serious amateur astronomy setup.

The observatory was built over a number of years, with the planning phase started in 2009 and first light occurring in December 2012. The observatory is in a great location, there are dark skies to the south, with little light pollution. The northern aspect is less ideal with the light dome from Kissimmee and Orlando encroaching on the view. However it is just a few minutes drive from St Cloud and is very accessible by road. As with most things it is a balance between location and accessibility and the KPO has got it just right.

The observatory itself is a multi-use facility split into two main parts. It consists: a 12 foot Observatory Dome with viewing platform; and a Warm Room / Studio / Workspace (often called a Man Cave). The Observatory Dome houses an 18 inch reflecting telescope, along with various smaller telescopes for finding and guiding, plus computers to control the entire system. The warm room is a bit of a misnomer as it is in Florida and has air-conditioning, but does serve to environmentally isolate the two sections. Both areas are connected via a local network to the main house which is where the power for the observatory originates.

The Observatory Dome has been installed some 10 feet above ground level with the observing deck 5 feet below. As the dome is round and the observing deck is square there are plenty of recesses for equipment computers and general storage, not forgetting the observing ladder. The observing ladder is required to gain access to the eyepiece of the telescope that may be positioned way above head height depending on what object the telescope is pointed at.

The telescope is mounted on what is known as a pier. The pier, in this case, is effectively a concrete pillar rising 10 feet above ground level having a 3 foot cubed footing for stability. The footing is isolated from the main floor of the observatory to ensure that movement in the Dome or Warm room are not transmitted to the telescope causing it to wobble. Having all this concrete may seem like overkill, but not when you see the telescope.

The telescope is an 18 inch reflector, meaning that light falls on to an 18 inch mirror. This is then concentrated onto the secondary mirror back near the top of the telescope. Having an 18 inch aperture means that the telescope itself is quite long and heavy, which in turn means it needs some hefty counter-balance weights. From this you can see the need for the substantial pier to mount it on.

Apart from the main telescope

The warm room / studio / Workspace at KP0: a place to work, learn, and relax. *Photo: Mike Barrett*

there are a number of other telescopes that piggy-back onto the main optic. These are used for finding the correct area of the sky and for locking the telescope onto a star to guide it accurately. In fact these telescopes are actually as big as a lot of amateur astronomers main telescopes.

The telescopes are all attached to a German Equatorial Mount. This allows the telescope to be set up so that when the star or object you want to view is in the center of the image all you need to do is to move the mount on one axis. This requires correct and precise alignment of the mount, which I will cover in a later article. To keep the object in view the mount has motors that move the telescope at the same rate that the stars move through the sky.

Obviously for the stars to be seen the dome needs to be opened. The dome has sliding doors that open to allow a portion of the sky to be visible. The telescope itself stays inside the dome protecting it from the wind and rain. Indeed should the weather turn nasty it is a quick and easy task to close the dome shutters and seal the telescope in the dome. As I mentioned above the mount moves at the same rate as the stars. This means that over time the telescope will move away from the open slot of the dome. To keep the telescope in the center of the opening the entire roof revolves on a wheeled system. This is currently a manual operation, but could become automated at some later point.

So with the telescope set up and running what do you do? Simple you go downstairs to the 'warm room' and have some fun while the telescope is automatically moving and taking pictures. With the networking facilities available in the observatory you can even control all the features of the telescopes. Kitted out with a large screen TV and full studio facilities you can either relax and enjoy or, as David often does, use it to present astronomy programmes as part of his outreach project. All you need to remember is to run upstairs every so often to nudge the dome round.

To see more details about the construction of the observatory visit the Kissimmee Park Observatory website at www.kpobservatory.org. You can contact David via FaceBook at www.facebook.com/kpobservatory to arrange to visit the observatory.

I have used just one example here to explain how an observatory works, but there are many similar establishments scattered around the World. Why not look up your local Astronomy Club on the internet and see if they have a programme of events for you to join in. If you are an educator why not approach your local club and see if they will come to your school and do a presentation. Our club gets lots of requests and we always manage to find some members to go out and spread the word!

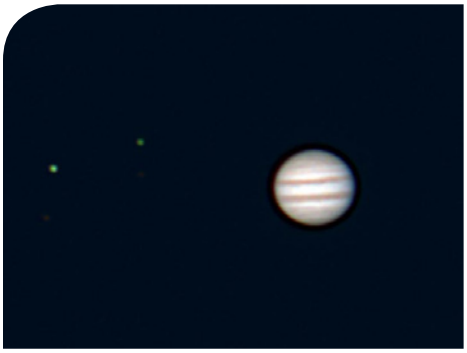
# jupiter: the gas giant

*By Mike Barrett*

Of all the planets that orbit around our Sun there are two that are easily visible and are fascinating objects to view. These are, of course, Saturn and Jupiter. Of these Jupiter is prominent in our night skies at the moment. At magnitude -2.06 it is the third brightest thing in the sky after the Moon and Venus.

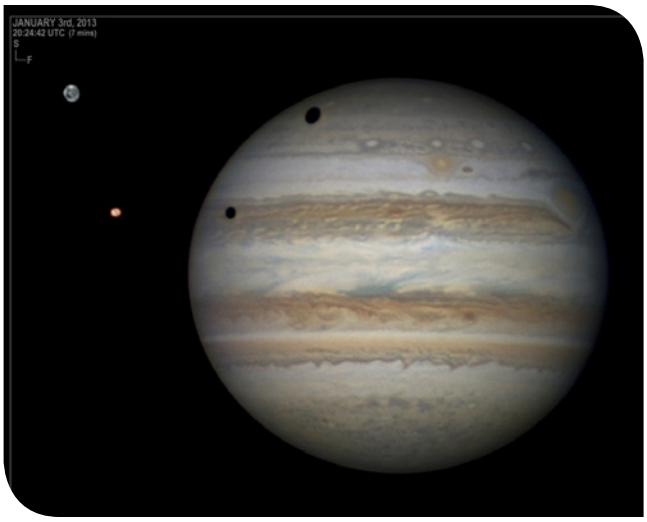
Currently Jupiter is in the constellation of Gemini forming a triangle with the bright stars Castor and Pollux. As the sun sets Jupiter is the first 'star' to be seen in the darkening skies to the east. As the night darkens further and the other stars pop into view Jupiter reigns the heavens as it slowly transits from east to west.

Jupiter is the fifth planet from the sun, and is the biggest in the solar system. As an indication of its size it has around two and a half times the mass of all the other planets added together and it's surface area is 122 times that of Earth. It is currently about 450,000,000 miles away from us, but this can vary depending on the relative positions of Jupiter and Earth in their orbits.



Jupiter from a webcam. *Photo: Mike Barrett*

Jupiter is known as a Gas Giant, and as such does not have a hard surface in the conventional way that Earth, Mars etc do. If you were able to survive in the atmosphere you would sink through the gaseous outer layers until you sunk towards the core of the planet. Assuming you were not crushed by the extreme pressures you would eventually find a point where you would float.




Jupiter moon transit. *Photo: Damien Peach*

Jupiter is mainly hydrogen (around 90%) and helium by volume in the atmosphere, with other elements appearing in the interior. It is speculated that the core of the planet could be metallic hydrogen.

Jupiter has 67 known moons, but of these there are four that are easily visible in binoculars or a telescope. These are the Galilean Moons of Io, Europa, Ganymede and Callisto. These are seen strung out in a line orbiting the planet. Sometimes the moons pass in front of Jupiter. This is known as a transit. The moon is difficult if not impossible to see when this happens, but the shadow of the moon can be clearly seen transiting the surface. Damian Peach managed to capture a fantastic image of Jupiter with two moons and the shadows. For more images of Jupiter visit Damian's site at www.damianpeach.com.

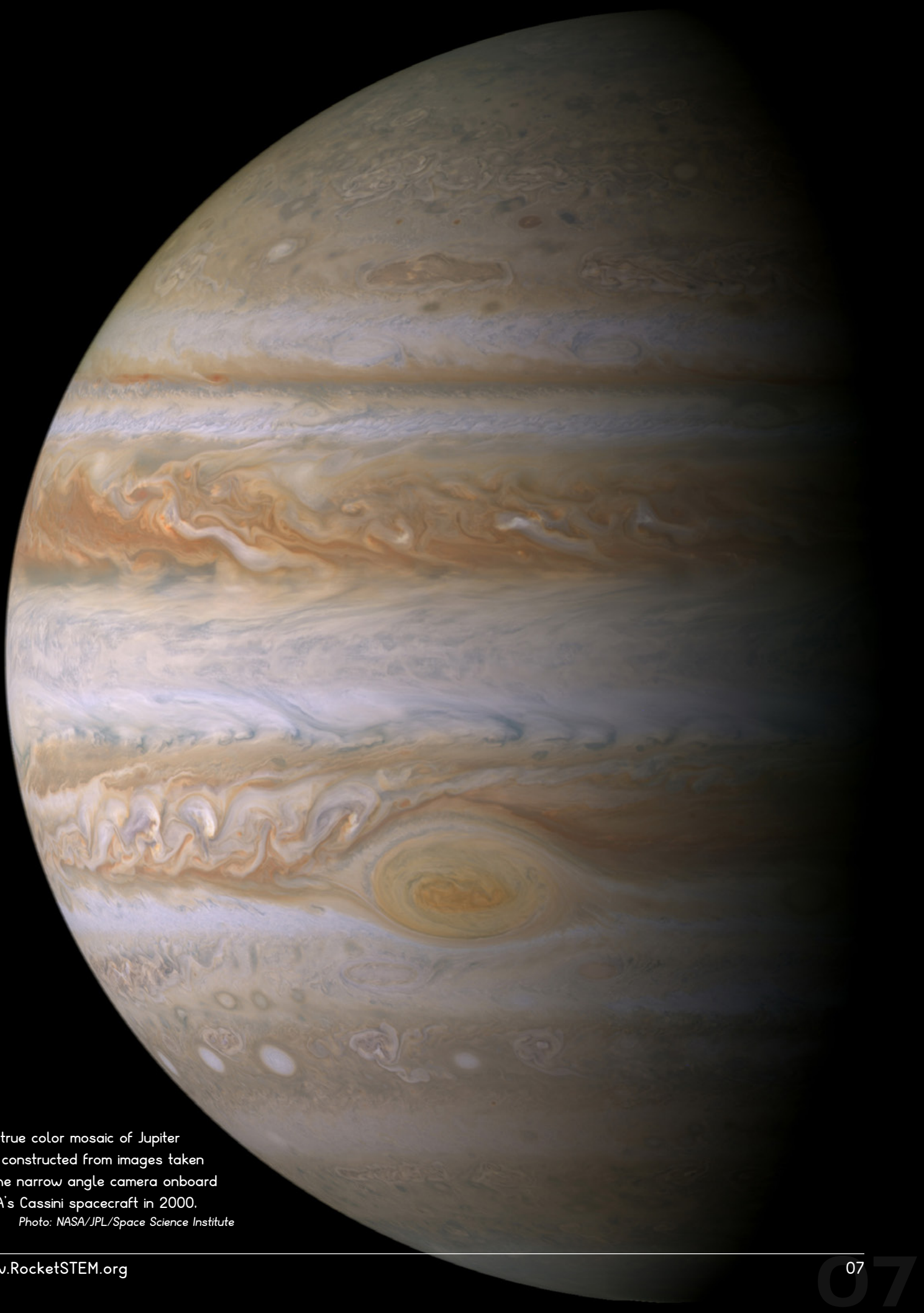
One of the beautiful features of Jupiter is the atmosphere, in particular the storms raging across it. One very well known feature is the Great Red Spot (GRS) which is the vortex of a storm that is larger than the Earth. This storm has been circulating for hundreds of years and is still going strong today. It is possible to see the GRS as it rotates around the planet. There is a calculator predicting when it will be in central view on the Sky and Telescope site at www.skyandtelescope.com/observing/objects/planets/3304091.html.

Other features that can be seen by the amateur are the main Northern and Southern Equatorial Belts, and the two polar regions. The Great Red Spot can be distinguished on a night with good seeing. With a larger telescope the temperate belts come into view as do some of the white ovals.

It is actually quite easy for an amateur astronomer to capture images of Jupiter with a modified webcam. I tried this myself on an old Microsoft webcam. The conversion cost about $15 and the results were almost as good as my $200 dedicated planetary camera. The image of Jupiter with Callisto and Ganymede shows what can be achieved with a webcam. The equatorial belts are well defined, as are the polar regions, the northern temperate belt can also be seen, but the southern one cannot.

*Photo: NASA/JPL*

Jupiter will be in the skies for some time now so why not take the opportunity to have a look at it. If you do not have a telescope then look up your local Astronomy Club, most will be very willing help.



This true color mosaic of Jupiter was constructed from images taken by the narrow angle camera onboard NASA's Cassini spacecraft in 2000.

*Photo: NASA/JPL/Space Science Institute*

NASA engineer Ernie Wright looks on as the first six flight ready James Webb Space Telescope's primary mirror segments are prepped to begin final cryogenic testing at NASA's Marshall Space Flight Center. This represents the first six of 18 segments that will form the telescope's primary mirror.

*Photo: NASA/MSFC/David Higginbotham*

# Meet NASA's James Webb Space Telescope

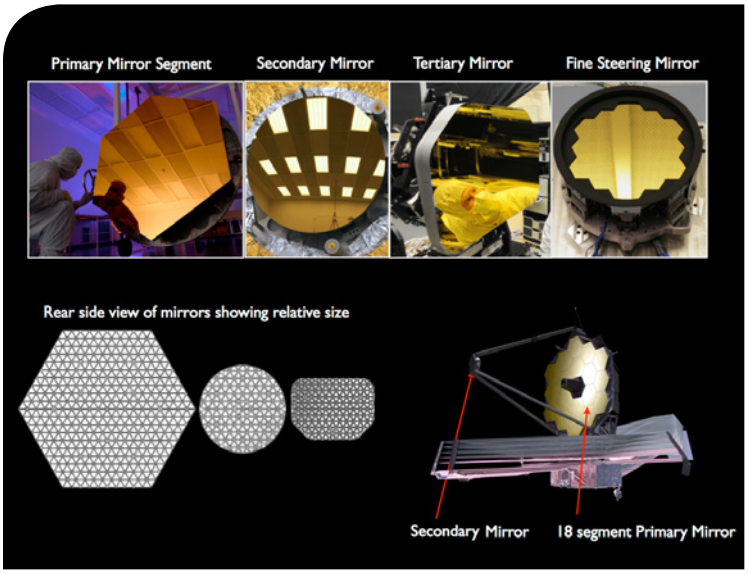
## Successor to the Hubble – Launch Date: 2018

*By Mike Killian*

In a 1.3 million cubic-foot cleanroom at NASA's Goddard Spaceflight Center in Greenbelt, Md., 18 gold-coated primary mirror segments await installation on NASA's James Webb Space Telescope. Those mirrors and the telescope's four science instruments just steps away, will become the most powerful space telescope ever built.

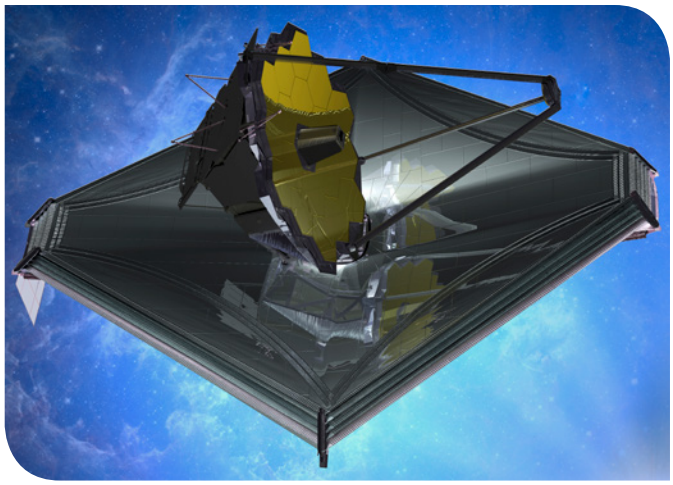
"The Hubble Space Telescope has already rewritten the science books. Going from Hubble to the James Webb Space Telescope is like going from a biplane to the jet engine," said Maryland Senator and Chairwoman of the Senate Appropriations Committee Barbara Mikulski at a news conference held at Goddard on Feb. 3. "The James Webb Space Telescope will keep us in the lead for astronomy for decades to come, spurring the innovation and technology that keep America's economy rolling."

With most of the major hardware now under one roof, assembly of the massive space-based observatory is expected to begin as soon as the telescope's structure arrives at Goddard, with assembly expected to be completed in 2016.




This image shows the four types of mirrors on the Webb telescope: a primary mirror segment, the secondary mirror, tertiary mirror and the fine steering mirror. On the bottom row are the three different mirror segments seen from the rear to illustrate the honeycomb structure that makes the mirrors both very light and mechanically stiff.

*Image NASA/Ball Aerospace/Tinsley*



An artist's impression of the James Webb Space Telescope.

*Image: Northrop Grumman*

Once complete, Webb – with its 69.5 ft x 46.5 ft instruments-protecting sunshield deployed – will be the size of a Boeing 737 airplane. Hubble, in comparison, is about the size of a large tractor-trailer truck or bus.

Webb's 6.5-meter diameter primary mirror will also be bigger, much bigger. The telescope will have nearly seven times more light collecting area than Hubble, allowing for unprecedented infrared observations of distant objects from the dawn of the universe some 14 billion years ago. Its mirror and instruments will capture images of the universe and break down the spectra of incoming light to analyze the properties of galaxies, stars, and the atmospheres of planets beyond our Solar System.

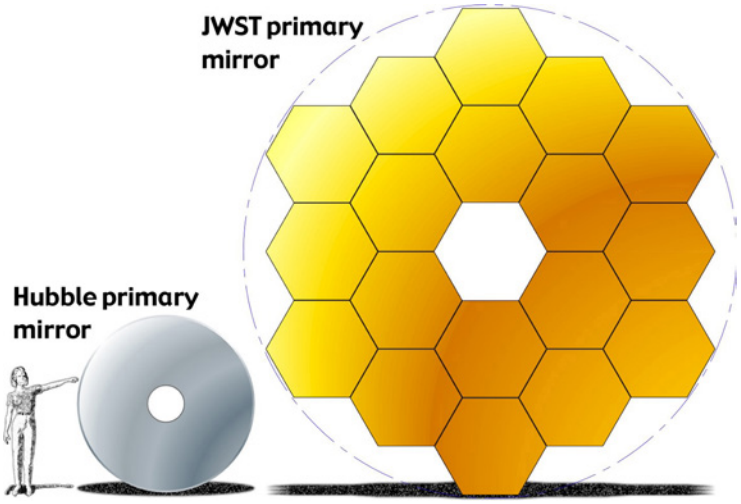
"The recent completion of the critical design review for Webb, and the delivery of all its instruments to Goddard, mark significant progress for this mission," said NASA Administrator Charles Bolden. "The design, build, delivery and testing of these components took meticulous planning and action here at Goddard and with teams across the country, as well as with our international partners. It's very exciting to see it all coming together."

A joint project between NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA), Webb will have been in planning, design, and development for over 20 years when it is launched atop an Ariane-5 rocket from Arianespace's ELA-3 launch complex at

Engineers worked meticulously to implant the James Webb Space Telescope's Mid-Infrared Instrument into the ISIM, or Integrated Science Instrument Module, in the cleanroom at NASA's Goddard Space Flight Center in Greenbelt, Md. *Photo: NASA/Chris Gunn*

the European Spaceport located near Kourou, French Guiana, in 2018.

The program has not been without its own share of problems and was nearly cancelled by the United States House of Representatives' appropriations committee on Commerce, Justice, and Science in 2011, citing "billions of dollars over budget and plagued by poor management" as the reasoning behind killing the program. Congress, however, reversed the cancellation plans and instead capped additional funding to complete the project at $8 billion – four times more expensive than originally proposed, with a new launch date at least seven years later than originally planned.




Size comparison of Hubble and Webb primary mirrors. *Image: NASA*

"Having the final mirror segments at Goddard is an exciting program milestone. It's the culmination of more than a decade of advanced optics manufacturing and testing work by teams of extremely dedicated engineers, technicians and scientists," said Eric Smith, acting program director and program scientist for the Webb Telescope at NASA Headquarters in Washington. "These mirrors are ready to meet up with the structure that will hold them incredibly stable, forming Webb's 6.5-meter-diameter primary mirror – the largest space telescope ever built."

The flight-ready mirrors, built by Ball Aerospace and Technologies Corporation in Boulder, Colo., began arriving at Goddard in the fall of 2012. The hexagon-shape of the mirrors, with 18 mirror segments making up one giant primary mirror, was no accident either – it was an intentional design because there is no rocket in the world large enough to loft a 6.5-meter mirror into space,

at least not in one piece. The 18 mirror segments can be folded up to fit into the launch vehicle and then unfold after launch, and once in space the segments will work together as a single large mirror.

Putting Webb into position for its observations is one thing, but getting the giant segmented mirror to focus on galaxies millions, even billions, of light-years away is another challenge all together. In order to ensure Webb achieves a single perfect focus, engineers will use six tiny mechanical motors, or actuators, attached to the back of each mirror piece to capture the images they expect Webb to produce.

"Aligning the primary mirror segments as though they are a single large mirror means each mirror is aligned to 1/10,000th the thickness of a human hair," said Lee Feinberg, Webb Optical Telescope Element Manager at NASA's Goddard Space Flight Center. "What's even more amazing is that the engineers and scientists working on the Webb telescope literally had to invent how to do this."

Another problem with "traditional" telescope mirrors is the fact that they are heavy. If Webb's mirror was made same as the Hubble, then it simply could not be launched. To get around this problem, the team at Northrop Grumman (the company that is leading the effort to build Webb) decided to make Webb's mirrors from Beryllium, which is a very strong lightweight metal. In order for the telescope's instruments to function properly, the observatory also needs to be kept very cold, -400 degrees Fahrenheit cold, and Beryllium holds its shape at those cryogenic temperatures and is a good conductor of electricity and heat.

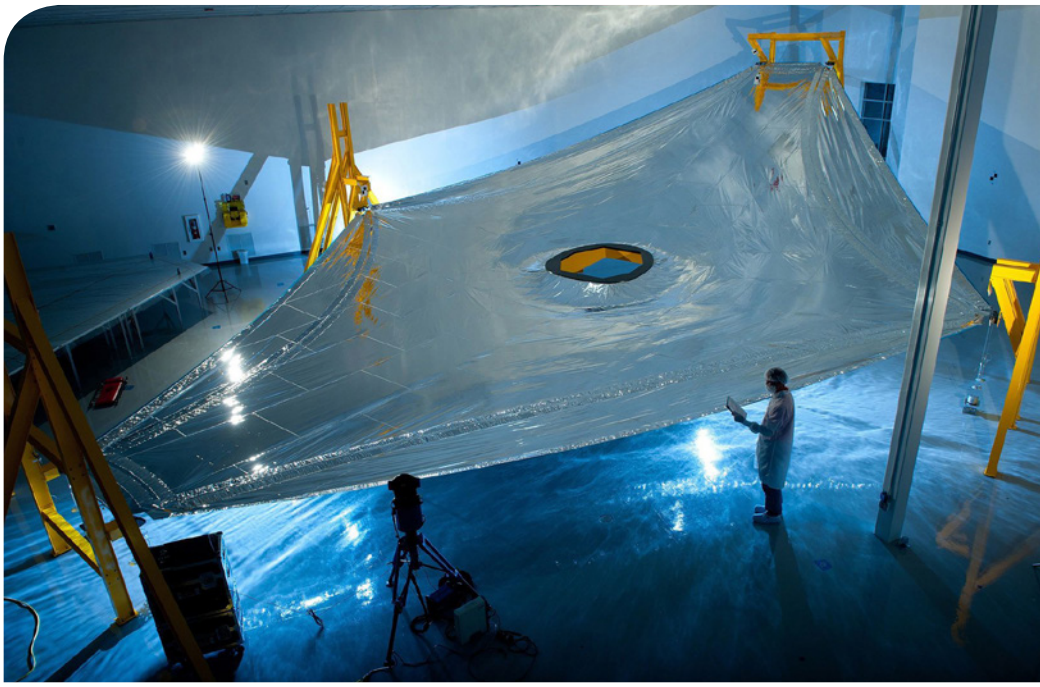
Gold coats the finished mirrors and is used to improve the mirror's reflection of infrared light.

ITT (formerly Kodak) will combine the 18 segments into one big mirror at Goddard once the mirror backing structure, built by ATK in their facility in Salt Lake City, Utah, is delivered. ITT will mount the mirror segments onto their proper place on the backing structure, which holds 12 segments in the middle part of the mirror and has two wings with three segments each (it's these wings that fold back so that the full mirror will fit into the payload fairing atop the Ariane-5 rocket).

Although the mirrors are not installed onto the body of the telescope yet, work to install Webb's four fragile science instruments began some time ago. The telescope's most sophisticated and technically challenging instrument – the Mid-Infrared Instrument (MIRI) – is now integrated into a large component of the telescope known as the science instrument payload, or Integrated Science Instrument Module (ISIM). The install took four hours to complete because the delicate operation required a surgical installation for precision and accuracy – MIRI had to be positioned to a tolerance of 25 microns, or one one-thousandth of an inch – which is less than the width of a human hair.

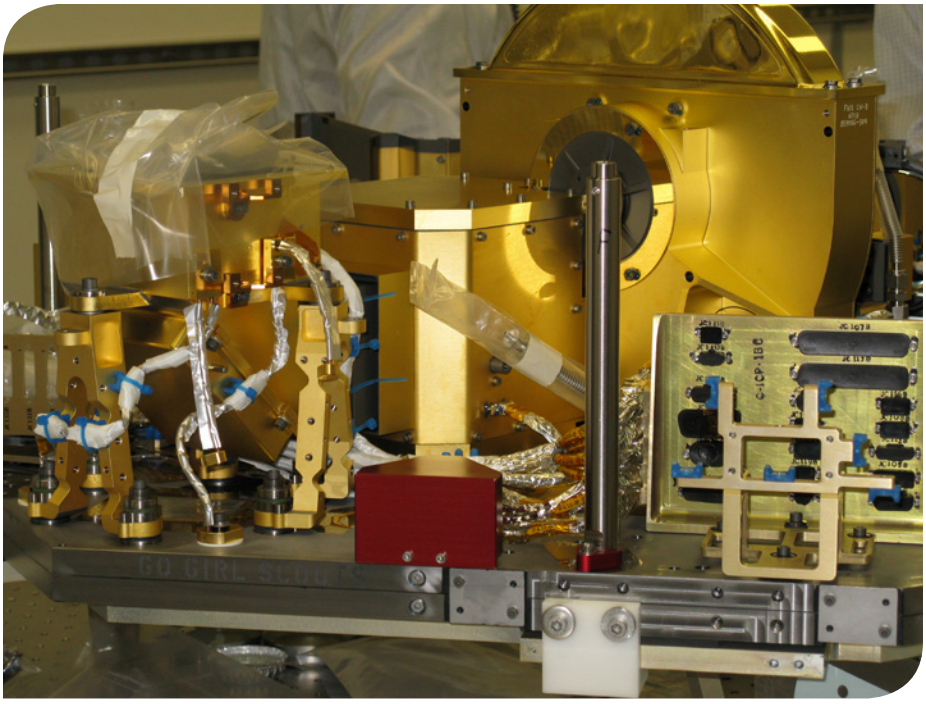
The ISIM itself acts like a chassis in a car to provide support and house all four of Webb's science instruments - it's the heart that enables the whole mission.

> *"Aligning the primary mirror segments as though they are a single large mirror means each mirror is aligned to 1/10,000th the thickness of a human hair."*
>
> – Lee Feinberg



A full-scale JWST sunshield membrane is deployed on the membrane test fixture ready for a precise measurement of its three dimensional shape.

*Image: Northrop Grumman Aerospace Systems*



NIRCam's flight modules are assembled and engraved permanently with "Go Girl Scouts" to honor the team's partners in STEM education. *Photo: NIRCam Team, University of Arizona*

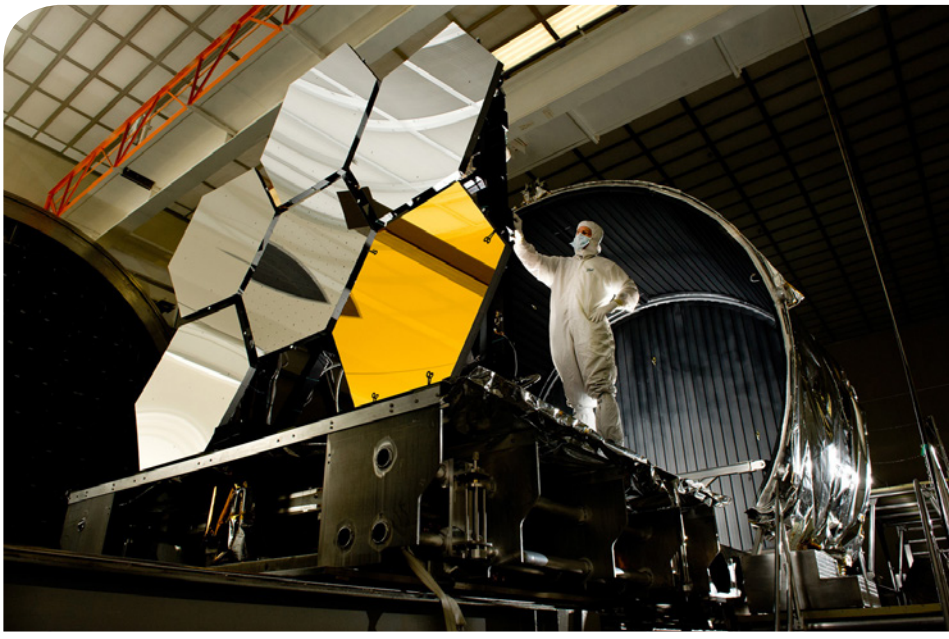
> *"We will be able to view the Universe at unprecedented sensitivity, which will help us to solve the mysteries of galaxy birth as well as the formation of solar systems – a key to understanding our own origins."*
>
> – Professor Martin Ward

Once the JWST is in space and MIRI goes operational it will open up the cosmos to astronomers by giving them views of colder, more distant objects than has ever been seen before. MIRI's camera and spectrograph will observe light with wavelengths in the mid-infrared range of the electromagnetic spectrum of five microns to 28 microns – longer wavelengths than a human eye can detect and even beyond the 0.6 micron to five micron wavelength range of Webb's other three instruments.

"Using this mid-infrared instrument we will be able to view the Universe at unprecedented sensitivity, which will help us to solve the mysteries of galaxy birth as well as the formation of solar systems – a key to understanding our own origins," said Professor Martin Ward, UK Science Co-Investigator on the MIRI project from the University of Arizona Department of Physics and Astronomy.

"The sensitive spectroscopy provided by MIRI is especially important as it contains many unique spectral and diagnostic features that will enable us to study the properties and materials around forming stars in extreme detail," said Dr Gillian Wright, European Consortium Principal Investigator for MIRI. "With MIRI onboard the JWST will continue the legacy of Hubble and become the world's benchmark for imaging the wonders of deep space."

MIRI's camera will provide wide-field, broadband imaging that will undoubtedly continue to impress humanity with incredible views of the universe same as Hubble. However, unlike Hubble's cameras, MIRI will see objects 10 to 100 times fainter than Hubble can see, and its spectrograph will enable medium-resolution spectroscopy, providing new physical details of the distant objects it will observe. Regions of



Ball Aerospace lead optical test engineer Dave Chaney inspects six primary mirror segments prior to cryogenic testing. *Photo: NASA/MSFC/David Higginbotham*

The mirrors that will fly aboard NASA's James Webb Space Telescope will allow the telescope to see farther away and further back in time to detect the light from the very first and most distant stars and galaxies. In this photo, an engineer's crystal clear reflection is seen on the surface of one of the primary mirror segments. The image is so clear you can see an expression of concentration in the engineer's face. Other engineers use flashlights to inspect the mirror segment. *Photo NASA/Chris Gunn*

obscured star formation, molecular hydrogen emission from previously unthinkable distances, the physics of protostars, and the sizes of Kuiper Belt objects and faint comets are all fair game to the power of the MIRI instrument.

Having the capability of both a spectrometer and an imager, basically being two instruments in one, gives MIRI the ability to point at an object in space to record both its image and spectrum. MIRI's capabilities will also allow it to see light emitted by molecules that reveal a wealth of physical information and can reveal the presence of life on other planets, in addition to seeing through dust which obscures key phenomena such as star formation. Physical properties of objects across the universe, including temperature, mass, and chemical composition of those objects, will all be studied by the giant telescope thanks to MIRI, which will hopefully answer long-standing questions that Hubble and the other great observatories alone cannot answer themselves.

The instrument will need to be cold – very cold – in order to operate correctly. MIRI will operate at a temperature of minus 270 degrees Celsius, and it will take approximately 200 days after launch to reach its optimal operating temperature. To ensure MIRI is protected from excess heat, it is housed in a thermal shield, which basically resembles foil. To obtain images and spectra in infrared light that is invisible to the human eye, the JWST must be cooled to a very low temperature (-383 F or -230 C) in order to avoid being blinded by their own infrared emission, and, since MIRI will operate over longer infrared wavelengths than the other three instruments, it must be made approximately 35 degrees colder than the rest of the ISIM.

"MIRI will enable Webb to distinguish the oldest galaxies from more evolved objects that have undergone several cycles of star birth and death," said Matt Greenhouse, ISIM project scientist at Goddard. "MIRI also will provide a unique window into the birth places of stars which are typically enshrouded by dust that shorter wavelength light cannot penetrate."

Webb passed its first significant mission milestone for 2014, a Spacecraft Critical Design Review (SCDR), several weeks ago. The week-long review by an independent panel of experts involved extensive discussions on all aspects of the spacecraft – details, designs, construction and testing plans, and the spacecraft's operating procedures were all reviewed in an effort to ensure the plans to finish construction would result in a vehicle that enables the powerful telescope and science instruments to deliver their unique and invaluable views of the universe.

# Jackee Mohl looks to the future as a Boeing structural engineer

*Interview by Sherry Valare*

*What do you get when a talented female engineer is one of the masterminds behind the design of an aircraft crossed between a helicopter and a jet fighter?*

*There exists a sort of "hybrid" military, tiltrotor aircraft that takes off and lands as a helicopter, and flies like an airplane. The Bell Boeing V-22 Osprey was designed by a team of engineers at Boeing to fulfill the needs of all four United States armed services in the Defense Department.*

*A tiltrotor aircraft creates its lift and propulsion with powered rotors (sometimes called proprotors) mounted upon rotating engine pods (or, nacelles) located at the end of fixed wings. When they are tilted forward they act as propellers to enable the V-22 to fly as an airplane, but when they tilt up, the aircraft performs landing and takeoff in the same way as a helicopter would.*

*A woman whose hands and mind have helped mold the V-22 into this multifunctional aircraft is Jackee Mohl, a structural engineer at Boeing. Mohl graduated from Massachusetts Institute of Technology (MIT) in 2008, where, in addition to her studies, she was captain of the MIT Women's Swim Team and held positions within the Society of Women Engineers MIT section.*

*Upon graduating from MIT, Jackee took a position at Boeing with the V-22 Osprey Helicopter Stress Analysis Group after interning with them for two summers in college. In late 2009, she assumed the position of Stress Lead for the V-22, where she remained through July 2012. Additionally, Mohl led the V-22 Engineering Producibility Tiger Team that worked on improving producibility issues in manufacturing, and was the focal for composite material allowable development for the V-22. Currently, Mohl has a role in supporting a proprietary program based in Saint Louis while she works in Philadelphia.*

Jackee Mohl is a structural engineer at Boeing working on the V-22 Osprey aircraft. *Photo: Boeing*

*In addition to working for Boeing, she is the chair of the Boeing-Philadelphia Diversity Council which won a Boeing Global Diversity Change Agent award in 2012 while she lead it, She also coorganized the annual Boeing Philadelphia Kickball Tournament as part of the 'Boeing on the Move' program, which has over 500 participating employees.*

*As a member of the Boeing Military Aircraft (BMA) Emerging Leaders Development Program's class of 2014, she led a special projects team, which focused on obtaining and managing projects with a significant business impact for BMA.*

*Mohl took the time out of her busy schedule to speak with RocketSTEM on her position at Boeing, the V-22, education, STEM outreach and extracurricular activities.*

**Q:** How did you get involved in subjects not traditionally thought of as "geared towards girls"?

**Mohl:** Throughout my entire life, I have been interested in math and science. I also have a sort of 'beat the boys' mentality. I wanted to prove that girls could do everything people thought only boys could do, even through my years as a middle and high school student. In high school, my Physics teacher became a mentor for me as I continued being drawn to math and science.

I have always been interested in how things work, and the principles behind how our physical world is governed. Based on that, I explored different career paths I could take and engineering was the one that combined my love of both subjects and used them for real world application.

**Q:** What kind of student were you in high school and what led you to attend Massachusetts Institute of Technology (MIT) for Mechanical Engineering?

**Mohl:** I maintained an 'A' average - I worked extremely hard. I was also a swimmer, so I swam 3-4 hours per day. Academics were always my number one priority, though. They were always what I strove to be

Crew members refuel an V-22 Osprey before a night mission in central Iraq. *Photo: U.S Navy/Chief Petty Officer Joe Kane*

the best in. Aside from liking math and science, I also had a natural knack for it, and I excelled at both subjects in high school.

MIT was not only the top engineering school in the country, it was also my dream to go there to take on the challenges the courses and professors presented to the students. I applied during my senior year of high school, and was accepted into what became an extremely rewarding experience. At that point in my academic career I had never received near the challenge academically as I did at MIT.

I polled upperclassmen to see what each major offered. I ended up choosing Mechanical Engineering because it was the most general of the engineering majors. I wasn't one hundred percent sure exactly what I was going to do, but I knew that degree would give me the option to go into many different industries to learn. What everyone considers when you think of an engineer, is usually a mechanical engineer.

**Q:** How did you become a structural engineer with Boeing?

**Mohl:** It was my position as an intern. Boeing is great about getting you involved in real projects that are happening – you are not just going around fetching people coffee – you are actually getting hands on experience with the aircraft.

Structural engineering very much spoke to my natural love of problem solving. Growing up, I loved math and science, and trying to figure out the answer to a problem I would see. That is what engineering is like, especially in structures. A problem will come up, we ask ourselves how we can solve it, and how we can make the product better.

**Q:** What do you do with the V-22? What is something "cool" about this aircraft?

**Mohl:** Since I am a structural engineer, I work on the design and structures of the aircraft. The greatest aspect of the V-22 is the fact that it is a transitional aircraft. It can be both a helicopter and an airplane at the same time.

Seeing the results of that in the field is pretty remarkable - the missions they can do - with this capability that they have never been able to do them with before.

Aerospace companies are always looking to the future. We are creating that future by asking ourselves what improvements we want to make down the line.

**Q:** You do a lot of STEM outreach, focusing on getting girls involved. Can you elaborate on this?

**Mohl:** I am an officer in the local chapter of society for Women Engineers and through that, we do a lot of work with Girl Scouts.

There are two main things we do. First, we do two engineering mini camps per year for high school girls. These students are from all over the tri-state area (Pennsylvania, New Jersey and Delaware plus Maryland, New York and Ohio). They come for a day and participate in different engineering projects taught to them by professional engineers and engineering students.

Last year, I was able to show a bridge building program to the students demonstrate how different trusses and bridges work – and also, how it relates to the structural side of airplane design as well. I also did a roller coaster design lab where the students were able to use foam tubes and marbles and design

different roller coasters to see how fast and far they could go. It really opens girls' eyes to the more fun aspects of engineering!

In addition to STEM outreach, the Society for Women Engineers does professional development for female engineers. We do different monthly meetings, talk about work and life balance, different technical topics. For example, last year, we talked about what kind of engineering goes into the Olympics.

also if they try tinkering around with things at home (with parental permission, of course!), it will help them gain a better understanding of how things function. Students can become researchers, teachers and engineers.

**Q:** You live in Philadelphia – are you an Eagles fan?

**Mohl:** Yes! Born and raised just outside of Philly so all Philly sports teams! I am a big sports fan especially

Jackee Mohl, a Philadelphia native, works for Boeing in her hometown. *Photo: Boeing*

**Q:** What would you tell a struggling student? One who lacks the math and science background, but so badly wants to do it. What is your advice?

**Mohl:** Some of the best engineers are people who have really good hands on understanding of how things work. Taking things apart, seeing how they are made, putting them back together – I know tons of people through high school and college that didn't have the book smarts or academics in that way, but they were so smart with knowing how things work. People that think like that make some of the best engineers.

A student is always going to need to get through the required course work, and working hard helps, but

college basketball! Oh everyone is going to hate me but I like Duke!

In my freshman year of college, in Boston, the Patriots were in the Super Bowl with the Eagles. The Eagles lost that game, and of course I was there in all of my Eagles gear.

**Q:** Well, I am a Steelers fan...

**Mohl:** I like Pittsburgh, actually!! I went there to the Carnegie School for Science during the summer before my senior year of high school. As a matter of fact, that is where my husband and I met!

**Q:** I hear you are a runner, how involved are you?

**Mohl:** I do marathons, but I am not very fast. I am coming up on my fourth marathon training. I really enjoy it, it is a great way to release the day and have time to yourself, and to be outside.

**Q:** Can you tell me a little bit about the V-22 aircraft?

**Mohl:** The first time I saw the V-22 fly, it was a really awesome experience, being able to see it take off like a helicopter, then all the sudden fly like an airplane. It was really very cool to be able to witness that.

There is an interesting fact about people who work for aerospace companies – you could build these things all day long, but to see one fly- we all flock to see them fly. There is nothing more exciting for us than seeing it in action.

Every time they have a flyover, everyone runs outside. We have the Chinook helicopter and the V-22 here and every time I still do this, even though I have seen them fly multiple times throughout the year. We devour reading about what our aircraft is doing. Our aircrafts are doing great humanitarian service. For example, the big rescue the V-22 did last year – we just can't get enough of news like that.

There is a lot of pride in what we do, it's really great.

**Q:** Are people able to tour the facility and see the V-22?

**Mohl:** It is tough because these are military aircraft, but robotics teams, engineers, students from engineering schools come in and show us their research which is also really interesting, because they sometimes are more cutting edge with the stuff they are doing in colleges. When they come in and show us research, we take them around the factories to show them that Boeing is a really cool place to work and what we do here.

**Q:** What is something you would like girls, kids, underdogs, etc. to know?

**Mohl:** Don't let anybody say you cannot do it because

Photo: U.S. Air Force/Senior Airman Julianne Showalter

# MV/CV-22 Osprey Data File

**First Flight:** March 19, 1989
**Delivered:** 2006
**Propulsion:** Two Rolls-Royce AE1107C turbo shaft engines
**Thrust:** More than 6,200 shaft horsepower per engine
**Accommodation:** crew: officer: two pilots; enlisted: two flight engineers
**Load:** 24 troops seated, 32 troops on floor, or 10,000 lbs. cargo
**Length:** Fuselage: 57.3 ft.
**Width:** Rotors turning: 84.7 ft.; Stowed: 18.4 ft.
**Height:** Nacelles vertical: 22.1 ft.; Stabilizer: 17.9 ft.
**Rotor Diameter:** 38.1 ft.
**Maximum Vertical Takeoff Weight:** 52,870 pounds (23,982 kilograms)
**Maximum Rolling Takeoff Weight:** 60,500 pounds (27,443 kilograms)
**Armament:** One .50 Cal Machine gun on ramp
**Max Cruise Speed:** 277 mph
**Ceiling:** 25,000 feet (7,620 meters)
**Mission Radius:** 500 miles with one internal auxiliary fuel tank. In flight refueling capable.
**Unit cost:** $89 million (fiscal 2005 dollars)

*Compiled by David Richards from U.S. Air Force documents*

everybody can. And I think girls make some of the best engineers I've seen throughout my career here, throughout college. They do some amazing stuff, and our efforts as women can not be underappreciated.

I had the fortune of having mentors along the way tell me that I could do it, and I try to give that back to the girls I now see at my outreach events.

I tell them that they can do it too.

**Q:** At any point in your career have you felt that being a woman held you back?

**Mohl:** Never. It has been equal ground the entire time. Never once have I felt like I wasn't respected. It doesn't even make a difference here, which is wonderful. It's really when you are growing up that boys get pushed towards math and science, while girls don't. Having people push me towards math and science has been the key part to me achieving what I've been able to.

**Q:** So, do you feel that having a mentor made a huge difference?

**Mohl:** Definitely – not only growing up, but also now at Boeing. I've mentored a couple of higher executive women here and now, seeing how much they have accomplished has helped me understand what I want my career path to be, as well. So yes, it has really been essential to my career.

*I think this sentiment by author C. Joybell C., "You may not know where you're going, but you know that so long as you spread your wings, the winds will carry you.", sums it up quite nicely.*

*Mohl is a great example of what a strong sense of commitment to a passion can help a person achieve. Not only does she excel in her field with her talent, she takes it a step further by giving back via her outreach efforts. She builds quality defense equipment and inspires girls to head in the direction of their engineering dreams. She may not have had her map drawn up the entire way through her academic career, but she clearly ended up exactly where she was meant to be.*

# NEIL DEGRASSE TYSON

*Image: Patrick Eccelsine/FOX*

# Tyson is a conduit to knowledge

*By Brandon Fibbs*

What to say about Neil deGrasse Tyson that hasn't already been said? These are the facts: Neil is the director of the Hayden Planetarium at New York City's American Museum of Natural History. He is an astrophysicist and New York Times bestselling author, former host of "NOVA ScienceNow," and frequent guest on such shows as Comedy Central's "The Daily Show" and "The Colbert Report," "Real Time with Bill Maher" and "Jeopardy." He is also, arguably, the country's most recognized science educator and that most rare of specimens — a celebrity scientist.

Those are the facts. But for me, Neil is so much more. He is also a dear friend and mentor. Neil has been a tremendous force in my adulthood, both a sounding board and a shaman to sea changes in my personal life and the philosophies that orient it.

I first met Neil deGrasse Tyson a decade ago at a large space symposium. At the intimate dinners and large public events that followed, in which politicians and movie stars hung on his every word just like those who happened to recognize him on the street, I've had the honor of observing how a teacher of the highest caliber speaks into the lives of his students.

The thing about Neil is, when you spend any amount of time with him, he makes you think you can do astrophysics.

You can't, of course. It is profoundly difficult stuff. But his explanations are so lucid and so clear that he reduces the most complex ideas to something shockingly intuitive. He does this not by dumbing the material down, but by elevating your aptitude; by transforming your perspective and the vantage point

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*Brandon Fibbs is a writer and producer in Los Angeles, California. A former film critic, he was the Research Coordinator on "Cosmos: A SpaceTime Odyssey," his very first Hollywood gig. He is currently working on the Science Channel's upcoming three-part documentary, "The New Race for Space."*

Image: Fox Broadcasting

*Tyson reduces the most complex ideas to something shockingly intuitive. He does this not by dumbing the material down, but by elevating your aptitude; by transforming your perspective.*

by which you come to the information. He transforms the profound into the practical and then back again.

Neil is a vivacious but always shockingly humble science evangelist, who nearly always eschews political agendas for the simpler and perhaps even more effective search for that elusive eureka moment that will cut through the flotsam and jetsam of our modern brains and hit us right where it can most elevate.

It is not hard to see why – though their tone and delivery are light years apart – Neil long ago stepped into the shoes of the late Carl Sagan. So it just made sense when it was announced that Neil would take the helm of the vessel that made Sagan a household name in the early 1980s – "Cosmos."

I had known for years that Neil and Ann Druyan, Sagan's widow, and Steven Soter, the original writers and producers, had been trying to get "Cosmos" off the ground again. We spoke about it often.

I was late into my 30s before I saw the original series for the first time. Growing up, Carl was a figure of mockery and buffoonery. "Cosmos" espoused ideas that challenged the worldview of my youth, and as a result, I had shunned it.

If I could only have told my younger self that I would not only one day watch every episode repeatedly, but end it in exactly the same manner – jaw slack, tears running down my face, brain vibrating within my skull.

The original "Cosmos: A Personal Voyage" was unique in the history of television.

It was not just a documentary, though it was that. It was not just a science show, or a history show, or an educational show, though it was all of these things. "Cosmos" didn't merely tell you about science or even show you; it immersed you. It didn't just teach; it transported.

People of faith frequently describe profound spiritual moments. "Cosmos" helped reveal that religion does not have the monopoly on awe. The show was a transcendent experience, describing how the world came to be and how you and I fit within it. Understanding how things work and the part you play in that process is liberating.

We came out on the other side, unfathomably insignificant, and yet incomprehensibly large as we recognized that the vast ocean in which we swam was something we could decipher and understand.

And it was beautiful beyond words. The scientific perspective, we came to realize, did not limit awe, it unleashed it. We truly are, to use just one of the show's many famous lines, a way for the cosmos to know itself. And yet, for all of its beauty and rapture, "Cosmos" was also uncompromising, taking aim at pseudoscience, mythology and irrationality of any stripe.

This new "Cosmos," three decades on, is the unmistakable progeny of the first, and continues that all-important legacy.

There has never been a more critical time for "Cosmos." Even more so than when it first aired, our society is one that is intrinsically and fundamentally built on the discoveries of science and the technological applications those discoveries generate. And yet, our age is one that is more suspicious and ignorant of that science than at any other time in our history. Conservatives rail against evolution and climate change. Liberals bemoan vaccines and GMOs.

Meanwhile poll after poll reveals that millions of Americans see horoscopes as accurate guides on which to base their decisions, yet do not know that it is the Earth that rotates around the Sun and not vice-versa.

"Cosmos: A SpaceTime Odyssey" is the antidote to such thinking.

Aside from the original series, "Cosmos" is like nothing you have ever seen on television before. It is as if a Hollywood blockbuster, born for the big screen, has been crammed into your television set. And why wouldn't it be? When the show was first announced, artisans came out of the woodwork, begging for a chance to lend their talents to it.

"Cosmos" is the result of film directors, producers, cinematographers, art directors, special effects artists and composers taking a respite from their movie careers to craft epic television because they believe in the message that strongly.

But beyond all the razzle dazzle of Hollywood computer wizardry (those bemoaning the CGI-heavy trailers for the new show forget that the original "Cosmos" used groundbreaking special effects for its time), "Cosmos" would still fail if it did not have, at its core, a message worth telling and a messenger worth listening to.

The message, delivered by the same scribes that penned the original, is as intoxicating and powerful as it ever was. And Neil deGrasse Tyson is a messenger for such a time as this – a teacher who understands that science is the best and most revelatory means we have for discerning the truth about you, the universe, and everything in between. Science is not a dogma, but rather a profound and profoundly moving tool by which hairless apes build towers of steel and glass into the sky, eradicate disease, extend lifespans, fly ourselves into deepest space, and penetrate the mysteries of our bodies and the universe.

Image: Richard Foreman, Jr./FOX

*It is not hard to see why Neil long ago stepped into the shoes of the late Carl Sagan.*

As the show's Research Coordinator, it was my job, among other things, to try and help bridge the gap between the deep and sometimes inscrutable scripts and the various vendors who would bring them to life.

In short, I got paid to come to work each day and study the universe; to sit down with the show's scientific advisors and learn everything I could about black holes, planetary accretion disks, evolution, and DNA, and pass that incandescent information on to others so that they might render visual effects and animated segments that were both thrilling to watch and as factual as possible. I hope I did well.

I had a good teacher in Neil. It is an education that I sincerely hope will continue for a great many years to come because I have so much more to learn.

It is among the greatest honors of my life to have contributed, in my own measly way, to this incredible work of art and science, and to have partnered with Neil on what, I think we would both agree, is one of the proudest achievements of our lives.

If "Cosmos" is the last great thing I do in this town, it will be enough.

# The wonders of the Cosmos:
# Neil deGrasse Tyson
## answers readers' questions

Image: Fox Broadcasting

Image: Richard Foreman, Jr./FOX

The pursuit of knowledge is just half the odyssey of a scientist. Being able to communicate that knowledge to a broader audience is the other half. Few, if any, excel better at the second part of the equation than the famed astrophysicist Neil deGrasse Tyson. It is little wonder then that he was chosen to be the host of the newest chapter of the "Cosmos" universe on television.

Even though he was in the midst of a worldwide publicity tour for the show, he made himself available to answer questions for RocketSTEM. Not one to waste the chance to connect our readers with such an esteemed scientist, we opened up the floodgates to let our readers submit their own questions. In less than 24 hours we were deluged with responses. In a contentious discussion comparable to picking Time's Person of the Year, we winnowed the list down to the best questions.

And without further ado, here are his responses...

**Q:** In the past you've stated that the universe called you while you were still in high school to become a scientist. For those students who have no interest in becoming a scientist or an engineer, how do we impart on them the value of still studying STEM subjects no matter what their career choice is?

**Tyson:** I was called by the universe at age 9. Long before high school. In spite of this, I claim no special solutions to the nation's educational woes, but I can assert without hesitation that people want to learn when flames of curiosity are lit within them. They become self-driven, taking ownership of their educational trajectory. We've all had teachers in our lives who did just that for us, but their numbers are typically countable on one hand. I count them as the first candidates for the walk-in cloning machine.

**Q:** What does a 'Eureka' or 'Aha!' moment feel like for you?

**Tyson:** Most scientific discovery, as Isaac Asimov perceptively noted, arise when, in response to new data, a scientists says, "That's odd". To utter the word Eureka implies that you found exactly what you were looking for, and that it happens in an instant. Most (nearly all) science does not unfold that way. Instead it's the long and slow analysis of data, extracting what you judge to be believable signals out of experimental noise. The real feeling worth describing is the act of obtaining the data – data that you know that nobody has obtained before. That's a state of unmatched anticipation and joy.

**Q:** What was the most rewarding part of doing the new "Cosmos", and why was it important to you to add another chapter to the storied legacy of the original "Cosmos"?

**Tyson:** I don't think of projects such as "Cosmos" as being rewarding to me. That's not the source of my motivation. I participated as a servant of the public's interest in the universe and as a conduit for those who did not know they could be interested in science, and for those who were sure they were not interested in science at all. If "Cosmos" succeeds, then the rewards are to society, who desperately needs - whether it knows it or not - a dose of science literacy to become better shepherds of our future on Earth.

**Q:** Concerning the conservation of mass: if the universe came from nothing, does that break that rule, or is it because in theory the universe was not a closed system yet? And is it now?

**Tyson:** We don't know where the universe came from. Recent research shows that if the net energy of the universe is zero (adding together all sources of positive and negative energy) then there's no problem creating a universe from nothing. (Energy and mass are equivalent, via $E=mc^{\wedge 2}$ ) so I've simply restated the question in terms of energy.) But why this universe? And why 13.8 billion years ago? These questions live on the cosmological frontier.

**Q:** How do we know that there is a black hole – Sagittarius A* – at the center of the Milky Way galaxy, and why should we feel safe that it poses no threat to our own solar system?

**Tyson:** The rapid movement of stars very near the galactic center gives us a measure of how much mass is there, and the volume of space it must occupy. Combining these two numbers, you get a black hole. In the case of Sagittarius A*, a supermassive black hole. The observations are hard, but the calculation is relatively easy. Black holes are not giant sucking machines. They do eat anything that wanders too close, but if you're on a stable galactic orbit far away from the beast, then you are safe.


Neil deGrase Tyson is hosting "Cosmos: A Spacetime Odysssey" three decades after Carl Sagan's original "Cosmos" aired on PBS.

**Q:** What, in your opinion, is the probability of life existing on Europa?

**Tyson:** 50:50

**Q:** If not on Europa, then where do you think we are most likely to first find evidence of life beyond Earth?

**Tyson:** Aquifers of Mars.

**Q:** What is your favorite scientific word, and why?

**Tyson:** syzygy

When written in script, all letters but one drop below the line. The word refers to three or more cosmic objects in mutual orbit, find themselves in a straight line.


**Q:** Which is more of a threat to the long term survival of mankind – hostile aliens invading Earth or artificially-intelligent robots turning on humanity?

**Tyson:** Asteroid impacts disrupting civilization. Human induced climate change disrupting civilization. Airborne virus with a long incubation period. (These are all bigger threats to humanity.)

It's hubris to believe that we would be of any interest to alien invaders. Any alien with technologies capable of visiting Earth from across the galaxy, upon observing the conduct of humans, will surely conclude that there's no sign of intelligent life on Earth, and go elsewhere.

If we build artificially intelligent robots, I'd instead turn to them for advice on how to run a better world.

**Q:** If we had a space telescope powerful enough to see 13.8 billion light-years away, would we be seeing the light coming from the moment of the Big Bang itself, or is this light forever unobservable?

**Tyson:** Any light from the big bang comes to us from about a half-billion years after the explosion, when the glow became transparent to light. To see farther back in time we cannot use telescopes that require light. The frontier of this effort is now in gravity wave and neutrino telescopes. These can penetrate the haze of light, taking us back to the first fractions of a second of time.

**Q:** If you could take a trip into space on any fictional or nonfictional spaceship, which would you choose, and why?

**Tyson:** The Ship of the Imagination. As featured in "Cosmos: A SpaceTime Odyssey" When you see it, you will know why.

**Q:** With an entire universe of knowledge to cover in just 13 hours, was there any specific subject you were not able to address in the new Cosmos? Or one where you would have liked to devote even more time explaining it than you did, but just weren't able to do so?

**Tyson:** We are not targeting all of cosmic knowledge, we instead explore how selected cosmic knowledge, obtained via the methods and tools of science, can foster a cosmic perspective, which, by many measures needs to be the centerpiece of wisdom for the 21st century.

**Q:** If you were to take a long journey into space, and weight and space were not a concern, what personal items would you desire to bring with you?

**Tyson:** Nothing comes to mind. I'm not particularly laden with personal items.

**Q:** You are given dictatorial control of the U.S. for one day. What is the first decree/policy you make to benefit the advancement of science in the United States?

**Tyson:** 10% of the federal budget each year should be invested in R&D – the kind that brings returns on investment across time periods longer than what can be expected for Corporate investment R&D. Five years, ten years, twenty years, fifty years. And in that investment, we would create a suite of launch vehicles suitable for any task in space that we have or can imagine, be it touristic, military, scientific, or otherwise commercial. Be it the Moon, Mars, asteroids, comets, outer planets, or libration points in space. That would transform the country and ultimately the world.

**Q:** As a kid, what scientific depiction or invention from sci-fi movies or television did you most want to have become real?

**Tyson:** Seen in the original StarTrek series - doors that automatically open when you approach them, and close when you walk away. Something ubiquitous today, but unimagined for most of the history of doors.

Beyond that, warp drives. I, too, want to be able to cross the Galaxy during a TV commercial.

**Q:** How can gravity cause galactic collisions when the universe is constantly stretching them away from each other?

**Tyson:** Some galaxies -- those that are closest to one another -- tend to be gravitationally bound. The expanding universe has no effect on them. Over the eons, they will ultimately collide, coalescing into one giant mass of stars and gas. We (Milky Way denizens) are on just such a collision course with the Andromeda galaxy.

**Q:** Why is there a growing consensus that there was something before the Big Bang, and what are some of the theories of what 'that' was?

**Tyson:** Quantum physics -- the most successful theory of the universe there ever was -- when combined with general relativity, offers compelling arguments for why our universe may be one of many, each with slightly different laws of physics from one another. This admits a multiverse that preceds the universe itself.

**Q:** Is time tangible? Why?

**Tyson:** If, by tangible, you mean that you can touch it, then no. But neither is space. They are coordinates of our lives.

**Q:** Are we as a species ready to send humans to live on Mars as a colony, never to return to Earth?

**Tyson:** No. Such a colony would be a habitat module, mimicking earth air, and providing a supply of water and food. If that's how you are going to do it, why not stay on Earth? Like taking a luxury Winnebago with satellite TV, a bathroom, and a kitchen on a camping trip. You are not camping.

The colonists who came to the new world did so, in part, to escape persecution. And they discovered, upon arriving, that you can breath the air, and eat the fruit, and use wood from the trees to make homes. A one-way trip to Mars has no such amenities. Consider also that Antarctica is wetter and balmier than the Martian surface, yet nobody is lining up to build condominiums there.

The takeaway here is that people live and work among us who want to take such a one-way trip. And I will always applaud ambition.

Image: Patrick Eccelsine/FOX

# Cosmos receiving largest global TV launch

Photo: FOX

*By Sam Mundell*

FOX Networks Group has announced the first ever simultaneous cross-network global event for "Cosmos: A Spacetime Odyssey" on Sunday March 9 at 9 p.m. ET/PT. Showing across multiple U.S. networks on Sunday, March 9, this exhilarating new series will make its debut on FOX International Channels and National Geographical Channels.

After the cross-network premiere event, "Cosmos: A Spacetime Odyssey" will continue its epic 13-episode run, airing Sundays (9-10 p.m. ET/PT) on FOX, and Mondays – with all-new bonus footage and behind-the-scenes content – on the National Geographic Channel (NGC) (10-11 p.m. ET/PT).

In addition to the 10 U.S. networks simulcasting the premiere episode, Fox International Channels (FIC) and National Geographic Channels International (NGCI),will premiere Cosmos on all 90 National Geographic Channels in 180 countries, as well as 120 FOX-branded channels in 125 countries, making this the largest global launch ever for a television series.

Rolling out immediately after the highly anticipated U.S. premiere, international markets will begin airing the premiere episode day and date on both FOX-branded and National Geographic Channels, concluding within one week of the domestic premiere event. The additional 12 episodes will air exclusively on National Geographic Channels outside the U.S.

It has been three decades since Carl Sagan's iconic and much loved exploration of our Universe in "Cosmos: A Personal Voyage" aired on our screens.

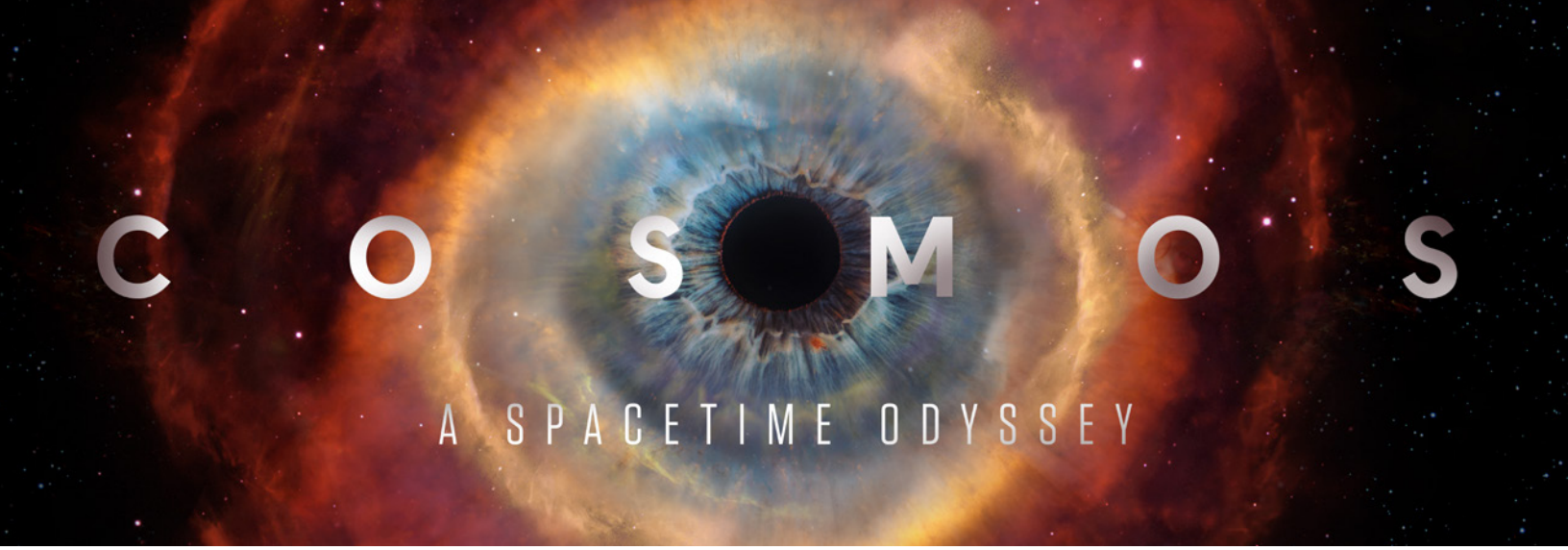
Thirty years later, and Seth McFarlane has teamed with Sagan's original collaborators – writer and executive producer Ann Druyan, and astronomer Steven Soter. Together they have conceived a new 13-part series that will become the long-awaited successor to Sagan's original breath taking series.

Hosted by world renowned astrophysicist Dr Neil deGrasse Tyson, "Cosmos" will take us on a new voyage of discovery. This is the saga of how we discovered the laws of nature, and how we found our coordinates in space and time.

As with the original ground breaking series, "Cosmos" continues on its quest to bring together never before told stories, and to transport its viewers across the Universe to reveal the Cosmos in all its splendour. Scientific concepts will continue to unite scepticism and wonder, whilst weaving rigorous science with the emotional and spiritual into a transcendent experience.

Once again, viewers will be enthralled by elements of the original series as the Cosmic Calendar and The Ship of the Imagination are reinvented.

Executive Producer Ann Druyan and astrophysicist Neil deGrasse Tyson have been drawing an enthusiastic response to "Cosmos: A Spacetime Odyssey" during a recent worldwide press tour. *Photo: National Geographic Channels*




*By Amjad P. Zaidi*

"Cosmos: A Spacetime Odyssey" beams onto our television screens on March 9 across 10 U.S. networks, including FOX and National Geographic Channel, with a multi-network simulcast in the United States.

Global releases will follow shortly after on National Geographic and FOX branded channels in 180 countries within a week of the U.S. premiere.

Fronted by famed astrophysicist Neil deGrasse Tyson, the show brings aboard new producer Seth McFarlane, and reunites writers/producers Ann Druyan and Steven Soter who worked with Carl Sagan on the original "Cosmos: A Personal Journey". Many more heralded creative talents have worked on creating the all new "Cosmos" for science hungry 21st century audiences. Following are teaser synopses of the incredible voyage that awaits us. It's time to get going again…

*All images by Fox Broadcasting. except where noted.*

# SPOILERS ALERT!

Do not continue reading if you would prefer to stay in the dark about the content of each episode.

## Episode 01: **STANDING UP IN THE MILKY WAY**

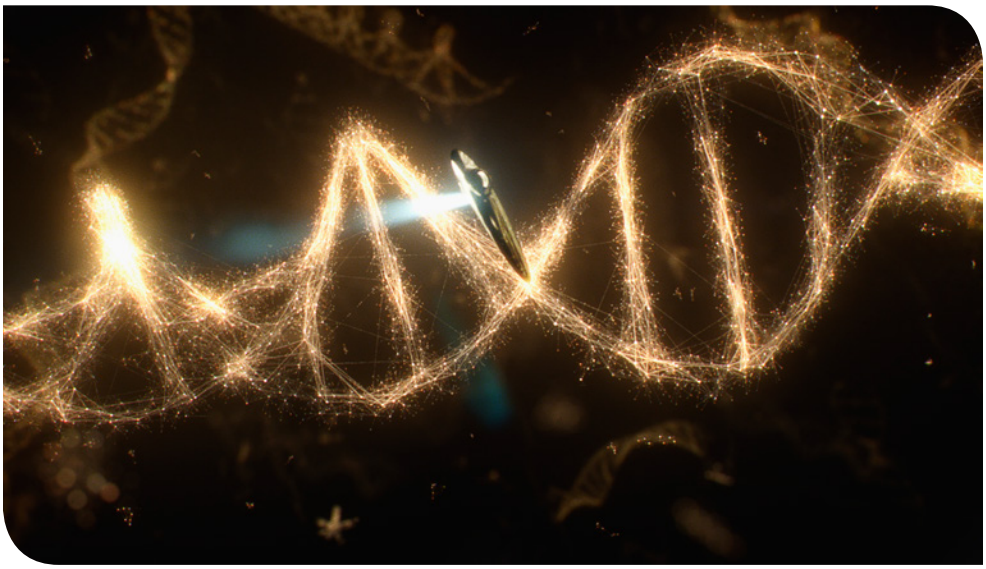
The iconic Ship Of The Imagination, once piloted by Dr. Carl Sagan has been refitted for a new 21st century voyage across space and time. Its shining legacy has been handed to an old student of Sagan's, Dr Neil deGrasse Tyson, who takes us – the next generation – ,on our first steps; a journey to discover our coordinates in space.

As we set sail for the stars a Window on the Past opens in the floor of our ship and we explore Italy's Renaissance period meeting Giordano Bruno. A friar and scholar, Bruno first glimpsed the true nature of the Cosmos, but in his time conveying these heretic ideas publicly was dangerous. They even invited death by execution. We learn how his sacrifice, zeal for truth, and zero tolerance for poor evidence and lack of scientific rigour have inspired the generations of scientists who followed him.

Neil continues our voyage and establishes our place in time. On a vast Cosmic Calendar, he shows us that each "month" from January to December represents more than a billion years. As we walk through our cosmic history, we discover that in the last seconds of December 31st, humans appear on this epic stage.

As we learn about the generations of truth seekers, we find that this community of minds stretches back to antiquity, and forward to the stars.

## Episode 02: **SOME OF THE THINGS THAT MOLECULES DO**



Over eons, artificial selection has transformed the wolf into the shepherd. Natural selection has evolved apes into humans. Our Ship of the Imagination continues its journey, now through the epochal layers of evolution to view the story of all life on a majestic cosmic canvas. Neil guides us through the grand Hall of Extinction; a graveyard for all those species that have been lost through time. The hall's five corridors commemorate the five great extinction catastrophes experienced by life on Earth. But there is a sixth dark and unnamed corridor. A reminder that our history is evolving and that our story may end down this corridor. These halls are the scattered dead branches from the Tree of Life.

From our vantage point we see a cataclysmic volcanic eruption approximately 250 million years ago in the ancient super-continent Pangaea. This triggered the Permian Mass Extinction Event where 97% of all life on Earth became extinct. We retrace the tale of those mass extinction survivors from the first single-celled organisms four billion years ago to us.

*"What a marvelous cooperative arrangement - plants and animals each inhaling each other's exhalations, a kind of planet-wide mutual mouth-to-stoma resuscitation, the entire elegant cycle powered by a star 150 million kilometers away."*

*– Carl Sagan, "Cosmos"*

## Episode 03: **WHEN KNOWLEDGE CONQUERED FEAR**

Our Ship Of The Imagination is in the dark distant depths of the Oort Cloud, halfway to our nearest celestial neighbour. Trillions of frozen dirty snowballs block our path. Neil pilots us on a rollercoaster ride chasing one of these comets during its fall towards our Sun across a million years.

Our understanding of these astronomic visitors is a result of the friendship between two 17th century geniuses, Edmond Halley and Sir Isaac Newton. Tormented by an intellectual competitor Robert Hooke, Newton was isolated and fearful of sharing his discoveries. Through Halley's friendship, generous and unfailing support, Newton overcame his fears and published the "Principia Mathematica." This three volume masterpiece based on the universal laws of motion, launched the Scientific Revolution. It empowered science to explore the Cosmos and forecast the future.

Our talent for automatic and spontaneous pattern recognition, both true and false, is a gift and a curse. We will examine this double-edged sword as we look back over the history of science. Finally in a nod to Newtonian laws, Neil will open a new Window On The Future in the ceiling of Our Ship to see a far distant and forecasted inevitability. Several billion years from now the Milky Way and Andromeda galaxies will collide, proving Newton's theories with stunning clarity.

## Episode 04: **HIDING IN THE LIGHT**

On our continuing voyages, we reopen the Window to the Past to see ancient Chinese history, where the first emperor of China violently suppressed free thought and speech with the first known book burning. Travelling westwards and up to the 11th century, we see Europe and Africa during the Golden Age of Islam, when Arabic was the language of mathematics and science. We meet one of that region's earliest physicists, Ibn al-Haytham. Described as the father of the Scientific Method, through enhanced optics he first understood how we see light and how it travels.

Continuing the themes of light and enlightenment, we discover William Herschel's breakthroughs on infrared in sunlight, and conclusions on invisible forms of light beyond what we can see. This episode also recites the tale of a poor 19th century Bavarian boy, rescued by royalty, who as an adult discovered unique signatures in starlight. He went on to found the science of astrophysics. His highly guarded discoveries locked away in an ancient abbey would capture the imagination of another genius (the hero of Episode 09), and lead to a world-altering key to the Cosmos itself.

*"When we look up at night and view the stars, everything we see is shinning because of distant nuclear fusion."*

*– Carl Sagan, "Cosmos"*

## Episode 05: **A SKY FULL OF GHOSTS**

Pushing forward into new realms, Neil takes us on a new trip into light, time and gravity; and we discover how they warp our universal perceptions.

We meet William Herschel again, a man who revealed that telescopes are time machines looking back into the distant past. We meet his young son John, who inspired by tales from his father will follow in his astronomical footsteps. But an ominous outsider skulks close by. All three are actors in the bizarre play showing how light plays with time and gravity.

Accelerating to near the speed of light, we take our Ship of the Imagination to faraway destinations seen only by telescopes. And for each journey we observe how events and life has unfolded on Earth in our absence. Then we push onwards, to the beginning of space and the very end of time itself.

All of us go about our lives in a gravity well. As toddlers we learn to stand tall against an invisible force that keeps us down. A teenage girl speeds off on her motorbike leaving the taunts of young boys behind. The beautiful Italian countryside whips past her as she experiences the phenomena related to relativistic travel through the Cosmos. But what would happen if the speed of light was infinite?

We change the gravity in New York City to see how it affects the lives of those in the Big Apple. Then we run into the shadowy figure from the late 18th century who concluded that black holes must exist. Taking our Ship of the Imagination to the event horizon of a black hole, we peer inward curiously. But then we are caught inescapably and are drawn over the edge and into it.

What is reality now? Anything must be possible. Time travelling backwards in Neil's life, we look into the day that changed his world forever. The day he met Carl Sagan…

## Episode 06: **DEEPER, DEEPER, DEEPER, STILL**

Neil dons a Cloak of Visibility and we see him purely as a being composed of atoms. The Ship of the Imagination journeys to micro space – to the bottom of a dewdrop – as we view the strange life there, and the struggle for life they are embroiled in.

Further still, Neil takes us on a journey traversing the complex neural networks in our brains, jumping synapses, from a molecule, to our memories of home. The ultimate scientific truth is that we never truly touch each other and this is shown in a tender love story between a young boy and girl. We look around and view the world differently as we've never seen it before. The plants and trees breathe around us.

In an ancient Grecian evening, Democritus tells a magnificent tale of reality's true nature that has been long since proven. Looking deep into his wine glass we see the intoxicating effects of the carbon atoms in his wine – and why carbon is essential to life on Earth. Neil drives us deeper to the inner chambers of atoms, to the cathedral of the nucleus and onward to the very heart of our Sun itself as we understand fusion.

Voyaging deep into the Earth, to a place unseen by human eyes, we discover the mystery of the neutrino. Our onward path leads us back in time to the Egyptian Temple of Ramses, where the nourishing rays from our star always halt before the Lord of Creation named Ptah. Deeper, deeper and deeper still into the mists of time, we come to that place on the Cosmic Calendar beyond which the unknown beckons – but a great barrier lies between us and the beginning of time itself.

*"The nitrogen in our DNA, the calcium in our teeth, the iron in our blood, the carbon in our apple pies were made in the interiors of collapsing stars. We are made of starstuff."*

*– Carl Sagan, "Cosmos"*

## Episode 07: **THE CLEAN ROOM**

Unsung heroes of science come in all forms, and this tale of a man from Iowa goes back to before the Earth was formed. Even to before the elements themselves were formed in stars. Earth's constantly changing nature has all but erased this origin tale but how do we know the true age of the Earth?

This story to discover the true age of our terran home spans centuries, until we stumble upon a guy from Iowa who develops an exacting but demanding method to do this. However, in his efforts to determine the truth, he finds a terrible crime has been done. Committed to the search for truth he will not stop, will not rest until the killers are found. Yet as he battles on, his efforts draw in an enemy, a man practiced in the misuse of science…

This grand saga shows us the highs and lows of science over the ages. It illuminates how one person using science as a tool for good can change the world for the better for all of us.

*Image: Richard Foreman. Jr./FOX*

## Episode 08: **SISTERS OF THE SUN**

The Pleiades Constellation – a guide for our ancient forebears. They looked into the night sky and used the Pleiades to invent agriculture. Their improved lot moved them from a people living under the heavens to a people living in dwellings, now disconnected from the stars above them.

Fables and traditions – from Halloween to the native American Kiowa nation's myth of the Devil's Tower – they all originated from the Pleiades. The ancient Greeks saw the constellation Orion chasing the Seven Sisters across the night sky. Legends ascribed by human storytellers to give meaning to these distant mysterious points of light.

We hear a new story; that of two 20th century female astronomers at Harvard who counted the stars. A young British lady joined them in their efforts, resisting the world's leading authority, and she taught the world about the real nature of the stars in our sky. Our Ship of the Imagination takes us on an exploration through stellar lifecycles including our own familiar Sun. Looking up through The Window on the Future we travel to Earth and live through the final ideal day on our mother planet. Exploring farther we stand witness to the tragic death of a binary star system.

In Australia we view the heavens with clarity akin to our ancestors' experiences. 7,500 light years away we see Eta Carina and its malevolent companion, torturing it with its strong gravity. Torn and twisted not to become a supernova, but one day to light up our skies as a hypernovae.

Neil samples the delights of a Tuscan vineyard showing how sunshine becomes moonshine. As we end this chapter of our travels, he guides us to the planet of a humdrum star orbiting a globular cluster. We see the most beautiful sight never seen until now; not a sunrise but a galaxy rise, as morning is brilliantly transformed not by one sun but two hundred billion suns! This is the rising of our Milky Way.

*"Writing is perhaps the greatest of human inventions, binding together people, citizens of distant epochs, who never knew one another. Books break the shackles of time."*

*– Carl Sagan, "Cosmos"*

## Episode 09: **THE ELECTRIC BOY**

Our 21st century world of hi-tech, satnavs, Twitter and Facebook, communication with our robotic ambassadors at the fringes of our solar system – these all are owed to the remarkable genius of Albert Einstein.

We start with Isaac Newton's problem of why an apple falls. Could this be the same riddle of why the planets are pulled towards the Sun as if on an invisible tether?

We move through Einstein's early childhood and see how his father sparked Albert's creative genius with the gift of a compass. How can the needle move if there is nothing but empty space behind it? There must be a deeply hidden reason to this.

We meet young Michael Faraday; born into obscure poverty he rose above his humble beginnings to invent the motor and the generator. He is our bridge from the old world to our world of high tech iPhones and computer tablets. Caught in the middle of 19th century English class warfare, he rose to scientific prominence, placing truth and ethics above all else, and rejected Queen Victoria's highest honours to make him a Knight of the Realm. His devotion to his mentor Sir Humphry Davy and his wife Sarah; his establishment of public science education for children; his personal

struggle with poor mental health; and redemptive breakthrough with Field Theory, are all milestones in his incredible, yet honest life.

On our journey through the past we encounter two strange beings, whose discoveries preceded Faraday's by centuries, and the fortunate child who converted Faraday's words into equations forming the basis of our society's reliance on electronic media and communication.

# Episode 10: **THE LOST WORLDS OF PLANET EARTH**

The Ship of the Imagination takes us on a tour through space and time, to all new frontiers, to grasp the history of Earth, writ small in its atoms, to the monumental scale of its oceans, continents, and the variety of inhabitants on our globe.

Visiting the primeval Carboniferous Era we encounter giant dragonflies and plants soaring hundreds of feet high. Yet this world will ensnare humans millions of years later. The arrival of lignin in the carbon cycle allows trees to take root, irrevocably altering the environment of our young planet forever. Our trek takes us to a world of purple oceans and green skies – ours; and we dive into an ocean – in Texas…


Image: Daniel Smith/FOX

We meet the genius who solved an ancient geological mystery but died before being accepted by his peers. And we'll meet the lady who proved his discoveries to be correct and exposed the largest feature on Earth. Diving our ship beneath the waves we'll explore the largest oceanic mountain range and descend into a mammoth underwater canyon where life has found a way to thrive in the dark cold. And the wonders around us continue to reveal themselves as we take the Ship of the Imagination into the Earth's mantle itself.

The young Earth was a rapidly changing series of worlds, active and destructive. We are just the latest inhabitants in its long history of renewal. We will recreate these old worlds and travel forward in our Ship of the Imagination to an older Earth, a quarter of a billion years in our far future.

*"If we long for our planet to be important, there is something we can do about it. We make our world significant by the courage of our questions and by the depth of our answers."*

*– Carl Sagan, "Cosmos"*

# Episode 11: **THE IMMORTALS**

Must we die? What must it be like to live forever? If there were timeless beings such as these in the Cosmos, what would their infinite existence be like across space and time?

To answer this question, we first visit the young and beautiful Akkadian Princess Enheduanna as she sails down the Euphrates River in 2300 B.C. Her place in history is forever immortalised by the words she wrote. 5,000 years after she passed away, she lives on, remembered by her poem of a goddess of love triumphant over the universe. Enheduanna is the first key in understanding the diverse interpretations of immortality.

The grand walls of Uruq (Iraq) rise up as we meet the heroic Gilgamesh. His personal journey is a quest for immortality. He meets a sage named Utnapushtim, who was instructed to build an ark, a millennium before Noah.

These historical figures have their own immortality thousands of years after their time as stories are written and reinterpreted across the generations. Their lives are coded within our own DNA.

More timeless stories have been given to us through the ages. An early 20th century meteorite strike in a remote Egyptian village held a story, but we could not read it for seventy years. Not until we sent our robot ambassadors to Mars and learned the language of the Red Planet. Immortality is preserved in our migrations from one place to the next. Life moves between planets and perhaps across the Cosmos itself.

1946: We record our first attempt to contact extra-terrestrial life. See what happened to that message. Great civilisations rise and fall. We ask do they have finite lifespans? We look at intelligent life on our own planet through the lens of a new Drake Equation and conclude the possibility of intelligent life across the whole observable universe.

We ponder about intelligent beings living in Red Dwarf star systems for trillions of years. How would they evolve over this seemingly infinite time? Would they unlock new doors to becoming the new immortals? We revisit the Cosmic Calendar of a future unseen and live through the first seconds of January 1st in a new Cosmic Year.

# Episode 12: **THE WORLD SET FREE**

A serene beach, a perfect day, but this is not our home. Welcome to Venus, but not as we know it, for this is Venus of old. Over time a runaway greenhouse effect inflicts mayhem on the planet's ecology, boiling off its great oceans, creating immense surface pressures 92 times that of Earth, and turning the sky into a poisonous fume.

Image: Richard Foreman, Jr./FOX

Safe inside our Ship of the Imagination, we survey this hellish wasteland before Neil flies us back to Earth to scale a huge structure built by a small life form. England's White Cliffs of Dover are seen as precious vaults of carbon.

Charles David Keeling reveals the Earth as one living breathing sphere. One breath happens annually. We examine the changing nature of Earth's atmosphere, our effect on it and explore the ramifications of global warming.

We look back at the long story of global warming and developing alternative energies as a remedy. Taking Our Ship through time we view critical points in Earth's history and choose to intervene. The Paris Exposition of 1878 is a major part of this story as Augustin Mouchot adapts his solar concentrator dish to printing presses and ice-making machines. In similar fashion, Frank Shuman exhibits his own irrigation machine in the Egyptian desert, powered by the Sun. And we visit Albert Einstein and Mileva Maric diligently working to solve the photo-electric effect. This is the key to all solar technologies.

And yet we have failed to listen to the story of science. It was science that heralded our technological age of advancements and enabled the impossible to become possible. We remember how, as Neil pilots our Ship of the Imagination in chase of the legendary Apollo 8 mission, on a date with destiny at the Moon.

Should we wake up from our slumber we will have a far superior world and existence for us and our progeny. Neil takes us on a dazzling ride to the resplendent future that is at our fingertips.

*"Exploration is in our nature. We began as wanderers, and we are wanderers still. We have lingered long enough on the shores of the cosmic ocean. We are ready at last to set sail for the stars."*

*– Carl Sagan, "Cosmos"*

# Episode 13: **UNAFRAID OF THE DARK**

On our voyages through space and time we have journeyed from the heart of an atom to the observable cosmic horizon, from the dawn of time itself to a future far far away. Now we are ready for an experiment. If thought through and performed correctly the grand understanding of our Cosmos is the ultimate reward.

In the 15th century, Martin Behaim created the first mapped globe of our world, months before Christopher Columbus set sail for Asia, but discovered the New World. Behaim's understanding of his then incomplete Earth was far more than our understanding of the Cosmos now. We take to the skies in Viktor Hess' hot air balloon and uncover the unknown cosmic rays. We visit the great Egyptian Library of Alexandria, a repository and magnet for the world's knowledge. Boarding our Ship of the Imagination for a final time we meet the crazy conundrum that is Fritz Zwicky, forecaster of supernovas, neutron stars, gravitational lensing and the mysterious dark matter.

It is dark matter's existence that is proving most elusive. The fearless Vera Rubin solved the mystery in the 1950's with her unique view. She looked at the stars anew and realised they were just foam on the crest of the wave; the true ocean was still out there and still unknown. All that we know, all that we think we know, a hundred billion galaxies, their innumerable stars, planets, moons – add them up and in all of human history we only have found a mere 4% of the unknown…

So much is still out there, and the vastness of this humbles us. It gives us much needed perspective that is absent from other human endeavours. Yet we have always been curious explorers, and the rich mysteries that call for our attention cannot be ignored. There is a hidden force in the universe that overwhelms gravity and is pushing the Cosmos apart. We cannot see it, but we know it is there waiting to be found.

Of all of our explorations, only two robotic ambassadors from Earth, Voyager 1 and 2 have travelled the vast distances to reach the cosmic shoreline at the ocean of interstellar space. The Voyagers transformed our understanding of astronomy with their epic travelogues from the depths of our Solar System. Yet perhaps their greatest gift was a simple one; an image of Earth from beyond Saturn, a Pale Blue Dot. Carl Sagan's legacy from the Voyager missions was this hard won image, an image which reframes our species' cosmic consciousness. Our signature messages on the Voyager Interstellar Golden Record will live on a billion years from now in a galaxy of untold possibilities.

As we come to the end of our "Spacetime Odyssey," we look back on the philosophy of science and how it is an uplifting and spiritual experience for all.

# Ann Druyan preserves the legacy of Sagan's 'Cosmos' with 'A Spacetime Odyssey'

*By Brandon Fibbs*

How often are you so moved by your job that you actually shed tears? On "Cosmos: A SpaceTime Odyssey," this was a fairly regular occurrence. It is impossible to work on something of such scale and import without being overcome, now and again, in the exact same way you hope your audience will be.

I will never forget the first day that Ann Druyan, Carl Sagan's widow and the writer and executive producer of both series, first arrived in Los Angeles from her home in Ithaca, New York. Ann has a bearing and poise all her own, at once professorial and maternal.

While the production office would eventually be transformed into a well-oiled machine – a sort of anthill of organized chaos that is representative of all Hollywood productions – it was then little more than a skeleton crew, assembled to prime the proverbial creative pumps. We gathered – the director, writers, producers and staff – in a room plastered from floor to ceiling with inspirational imagery, research photographs and concept art.

As we took our places around the table, and I prepared to read the first episode aloud, Ann, in a tone that is both nurturing and instructive, told us stories about her life with Carl, the experiences they'd had making the first show, and how she wanted to honor his enduring legacy with this new work. "Carl would be so, so proud of each of you," she said, "and what we are all about to undertake here." Suddenly the room became blurry and I realized I had tears in my eyes.

This was not just another television show that will air and be just as quickly forgotten. It was clear, even in the very beginning, that we were participating in something incredibly special and unique, a work of exquisite narrative power and profound human insight, a piece of entertainment that literally has the power to change the way people see themselves and their place in the universe.

No one on this planet was closer to Carl Sagan than Ann Druyan. Her intimacy has preserved his spirit with a fierce passion and uncompromising resolve, and she poured that essence into this new work. She was the keeper of Carl's flame, and it was the plumb line that guided everything we did.

One of my favorite memories was of being present in the screening room when a rough cut of a scene was shown describing how a then young Neil deGrasse Tyson first met the famous Cornell astronomer. It was a beautiful and ephemeral moment, and in the dark of the theater, I saw Ann reach across to tightly squeeze the hand of our director, Brannon Braga, before wiping tears from her eyes. We'd gotten it right.

> *"We've designed 'Cosmos' to have a very long shelf life. It's not about the latest hypothesis. It's about something else. It's about the aggregate of human discovery"*
>
> – Ann Druyan

Ann worked doggedly and tirelessly, overseeing nearly every aspect of the production. Hers was the sort of unbending tenacity that came both from inexperience – recall that the first "Cosmos" was made more than three decades ago and for PBS, not a behemoth like FOX – and an absolute and uncompromising vision for every detail of the far distant finish line. And yet, despite this resolve, Ann still managed to produce a work that can stand entirely on its own, unmistakably an offspring of the original series, but with a tone, energy and voice all its own.

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*Brandon Fibbs is a writer and producer in Los Angeles, California. He was the Research Coordinator on "Cosmos: A SpaceTime Odyssey," his very first Hollywood gig.*

*Image: Patrick Eccelsine/FOX*


Image: SV Studios

# One man's journey to make a film

*By Tony Rice*

When filmmaker Stephen Van Vuuren first saw images of Saturn retuned by the Cassini spacecraft, he saw something more in them. He not only saw the beauty of the ringed planet, he saw a motion picture camera flying through space.

Van Vuuren grew up in Johannesburg, South Africa, with dreams of being an astronaut. He was accepted at MIT to major in astrophysics, but Stanley Kubrick's film "2001: A Space Odyssey" changed his mind. He came to the United States to study filmmaking. Today he's realizing both dreams and taking audiences along for the ride.

Stephen Van Vuuren works in his basement studio on the IMAX film "In Saturn's Rings" which will be released this July. *Photo: SV Studios*

"In Saturn's Rings" is a non-profit film which animates over a million photographs from a variety of sources including those from Cassini which first inspired Van Vurren. Some frames of the movie are from a single photograph. Others, such as the movie's visualization of the Big Bang incorporate thousands of images from the Hubble Space Telescope. The film also draws from imagery from the Lunar Reconnaissance Orbiter, Messenger, Suomi NPP, Solar Dynamics Observatory, Mars Reconnaissance Orbiter, Venus Express, Rosetta, Dawn, Galileo, Voyager and Apollo programs.

A subject this big requires a big presentation. The film is being made for giant screens like IMAX theaters, fulldome planetariums, and 4k digital cinemas. This requires a tremendous amount of storage space on the computers being used to create the film.

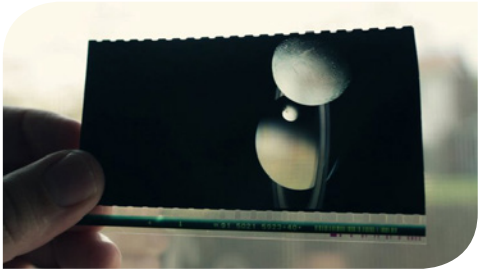
"The final film will consume about 50 to 65 Terrabytes" says Van Vuuren. That's enough space for over 200 Blu-ray discs, 100,000 CDs or the text in about 250 million books.

Van Vuuren describes the film as a work of art created through science. A soaring performance of Samuel Barber's "Adagio for Strings" by the Greensboro (North Carolina) Symphony accompanies the audience as they fly along with the Apollo 17 astronauts,


Image: Colin Legg/SV Studios

above the Earth with a Space Shuttle orbiter and as they enjoy a front row seat to the Big Bang.

Images don't just come from NASA and the European Space Agency. Astrophotographer Colin Legg ventured hundreds of miles into Australia's Gibson Desert to capture the night sky free of any light pollution. Over 11 days and nights the custom built rig consisting of 5 digital SLR cameras tracked the sky producing over 111,000 images. Back in Greensboro eight computers are spending six weeks stitching those individual photos together in a super high-resolution image with a stunning view of the Milky Way.



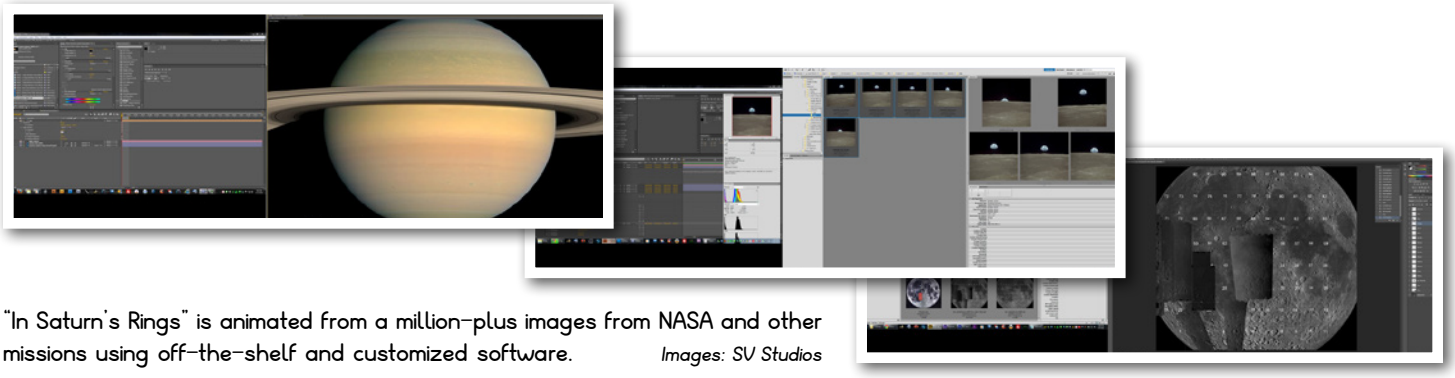
IMAX film is about 10 times larger than standard 35-millimeter film. *Image: SV Studios*

Early animation tests were featured on NASA's Astronomy Photo of the Day and went viral. Two million plays later, a team of more than 35 have volunteered their time and talents in processing images after seeing those early clips.

It all comes together in the basement of Van Vuuren's Greensboro, North Carolina condominium on an array of computers, most built by Stephen himself.

"In Saturn's Rings" is scheduled to premier July 2014 and will be rolled out to planetariums, museums, science centers and other large screen theaters for years to come. It is dedicated to the memory of Carl Sagan and Stanley Kubrick.

For more information, please visit the film's website at: www.insaturnsrings.com/. The movie trailer may viewed at: www.youtube.com/watch?v=aJjeo2Br2AY/.



"In Saturn's Rings" is animated from a million-plus images from NASA and other missions using off-the-shelf and customized software. *Images: SV Studios*

Images from multiple spacecraft were combined with images captured from Earth to create this view.

*Image: NASA/JPL/SV Studios et al.*


*Image: NASA/JPL/SV Studios et al.*

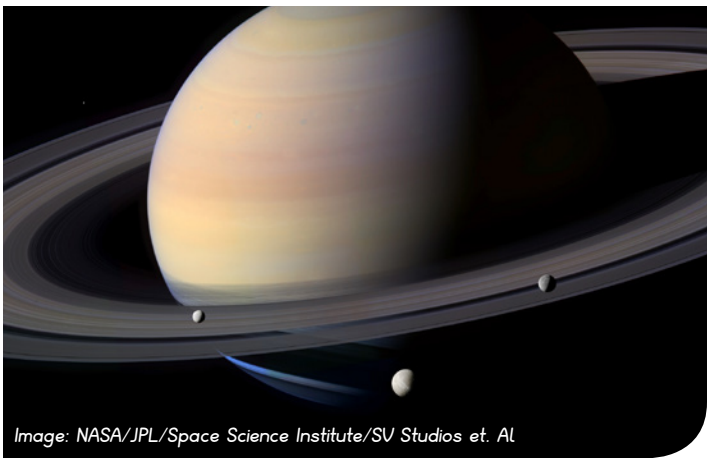


*Image: NASA/JPL/Space Science Institute/SV Studios et. Al*


*By Nicole Solomon*

By all accounts, Team Unicorn should not exist. Like the fabled unicorns of ancient mythology, geek girls are also supposed to be the stuff of myth and legend, whispered about in reverent tones at Comic Con, but only ever seen fleetingly out of the corner of one's eye. And yet, these magical beasts are very real. They bludgeon bad guys, rescue kittens, and regularly save the Universe – all in a day's work for this intergalactic force of awesome.

Formed in Los Angeles, California, in 2010, the original members of Team Unicorn were actresses and singers Clare Grant, Milynn Sarley, Rileah Vanderbilt and Michele Boyd. The group is best known for their parody songs, including "G33k & G4m3r Girls" which spoofed Katy Perry's "California Gurls." Filled with geek cultural references, the song is a homage to women who love science fiction, manga, and especially gaming. Other YouTube hits include "A Very Zombie Holiday", "SuperHarmony" (mocking those ubiquitous eHarmony commercials), "Alien Beach Crashers" (which spoofs the frothy 1950's beach party songs institutionalized byAnnette Funicello), and a "Starship Troopers" parody titled, "The UniCorps Wants YOU!"

Adult Swim has announced that a Team Unicorn live action / animation pilot is in the works, from the creators of "Robot Chicken."

I recently sat down with the unicorns for a lively discussion about gaming, music, movies and their love for space.

# Clare Grant

**Q:** Marvel or DC?

**Clare:** I'm a Marvel girl. I grew up reading Marvel comics, and love their relatable characters and storytelling. But DC has created the most iconic superheroes of all time, so I have mad respect for them as well. Plus-DC has Batman.

**Q:** Favorite astronaut, scientist, engineer or inventor?

**Clare:** Does my college physics professor count? Because he introduced me to physics, which I fell in love with, and made me realize how much I like science. But if I had to pick someone the rest of the world knows, right now it would be Nikola Tesla. He is fascinating.

**Q:** Favorite planet?

**Clare:** My favorite planet is actually Saturn's moon, Titan. I grew up reading a lot of Kurt Vonnegut, and love Sirens of Titan so much, I adapted it in to a play that I directed in college. That book romanticized Titan in a way that will stick with me forever.

**Q:** Star Wars or Star Trek?

**Clare:** I am definitely more passionate about Star Wars, as it is one of the most influential movies of my life, and something that bonded me with my younger brothers and sisters. And now it is something that I share with my husband. But I also grew up watching Star Trek with my Dad, who is a huge Trekker, so I have a lot of love for Star Trek.

**Q:** Favorite space agency?

**Clare:** NASA. I went to Space Camp in Huntsville for a field trip and was immediately fascinated by space . When I moved from Memphis to Houston, my new neighborhood & schools backed up to NASA property. My Intermediate school was even called Space Center. Being completely immersed in NASA like I was during that time, I fell even more in love with the agency and everything it stands for.

**Q:** If you were on a long space journey, what food and beverage could you not live with out?

**Clare:** Coffee, chocolate & bacon.

**Q:** Build things or destroy them?

**Clare:** I've been taking things a part just to put them back together again since I was a little girl, beginning with my NES. Getting my first computer was fun because I immediately took it apart, switching parts added things to it.

**Q:** Favorite space mission?

**Clare:** I saw the final shuttle mission launch, STS-135, and it was beautiful. But STS-134 is the most memorable for me personally. I went down to Florida with my husband and a couple friends for the launch for STS-134, and STS-135. STS-134 was scrubbed, so instead, the kind folks at NASA gave us the most incredible tour of Kennedy Space Center and of the Air Force base down there. We sat in the cockpit of Discovery, touched the belly of Atlantis, played flight director in command central, and got to tour old launch sites. AND, it was on my husband and I's first wedding anniversary. Nothing could have been more perfect or magical.

**Q:** Favorite video game?

**Clare:** Hardest question ever! Most played game: Super Mario Bros. 3. Favorite childhood game: Super Metroid. Most influential game: Dragon Warrior 1 or Final Fantasy 2. Favorite post-cartridge days game: Castlevania: Symphony of the Night. Favorite recent game: the most recent Tomb Raider.

**Q:** If you could travel to any single place in the solar system where would you go?

**Clare:** Sirius. What's up there????

**Q:** The Universe; will it end in fire or ice? The Great Contraction or The Great Freeze?

**Clare:** FIRE!!! EXPLOSIONS!!

# Rileah Vanderbilt

**Q:** Favorite space movie?

**Rileah**: "Space Camp." You really get to pilot a Shuttle to space if you go to camp, right?

**Q:** Star Wars or Star Trek?

**Rileah**: Star Wars. It will always be my first Sci-Fi love.

**Q:** The Universe; will it end in fire or ice? The Great Contraction or The Great Freeze?

**Rileah**: The Great Freeze. An expanding universe is a cold universe.

**Q:** Superhero or a villain?

**Rileah**: Superhero. With great power comes great responsibility.

**Q:** Favorite astronaut, scientist, engineer or inventor?

**Rileah**: There's a special place in my heart for Nikola Tesla. I love an underdog.

**Q:** Favorite planet?

**Rileah**: Earth. Nothing we've found yet, is as beautiful or unique as our little blue planet.

**Q:** Aliens or robots?

**Rileah**: Aliens. The idea of extraterrestrial life is pretty epic.

**Q:** Favorite space mission?

**Rileah**: Apollo 11. It was the first time anyone had stepped foot on another celestial body before. Such a profound moment for mankind.

**Q:** If you could travel to Mars what five things would you take with you?

**Rileah**: Toothbrush, footie pajamas, camera, my media library and the hubby.

**Q:** Favorite video game?

**Rileah**: Mario Bros. 3

**Q:** If you were on a long space journey, what food and beverage could you not live with out?

**Rileah**: Ramen noodles and green tea.

**Q:** Marvel or DC?

**Rileah**: This one's tough. Batman is my all time favorite comic character, and I love Wonder Woman, so I'll have to go DC.

**Q:** If you could travel to any single place in the solar system where would you go?

**Rileah**: Spring break on Mars!

**Q:** What astronaut would you date?

**Rileah**: Neil Armstrong. I think you get cool points from your friends if you date the guy who was the first to walk on the moon.

**Q:** If you were a spacecraft which one would you be?

**Rileah**: Voyager 1. To be the first to be the first to travel into Interstellar Space is pretty awesome.

**Q:** If you could play any part in any sci-fi / space film or TV show, past, present or future, what would it be and why?

**Rileah**: Can I be Han Solo?? I'd like that. He has the best ship and a wookiee for a best friend.

# Milynn Sarley

**Q:** Aliens or robots?

**Milynn:** Robots, I'm really only bidding my time staying alive till I can download my consciousness into an organic robot and live forever. Muahahaahaha.

**Q:** Build things or destroy them?

**Milynn:** Destroy how? With FIRE? I'm listening….

**Q:** Favorite Astronaut, scientist, engineer or inventor?

**Milynn:** Bobak Ferdowsi but only because he paid me to say that. #science

**Q:** The Universe; will it end in fire or ice? The Great Contraction or The Great Freeze?

**Milynn:** The Universe will end not with a bang but with a whimper...or from dark matter. Almost definitely dark matter.

**Q:** Marvel or DC?

**Milynn:** Marvel. I've been obsessed with the X-men franchise since childhood.

**Q:** If you could travel to Mars what five things would you take with you?

**Milynn:** Five puppies. I mean…puppies are always the right answer…right? RIGHT?!

**Q:** Favorite video game?

**Milynn:** I'm not good at picking favorites but I would say FFVII had one of the biggest impacts on my life. It changed the whole way of how I viewed gaming and created the monster I am today.

**Q:** Favorite planet?

**Milynn:** Gliese 581 g. It makes me dream dreams about the future, when intergalactic travel will be be a reality and the exploration for intelligent life can truly begin.

**Q:** Superhero or a villain?

**Milynn:** Villain. Full Villain.

**Q:** If you were on a long space journey, what food and beverage could you not live with out?

**Milynn:** If i were on a long space journey I would expect to be put into a lovely cryo-sleep until I had reached my destination. Should that technology be lacking, I suppose an endless supply of Jameson would be and acceptable alternative.

**Q:** If you could travel to any single place in the solar system where would you go?

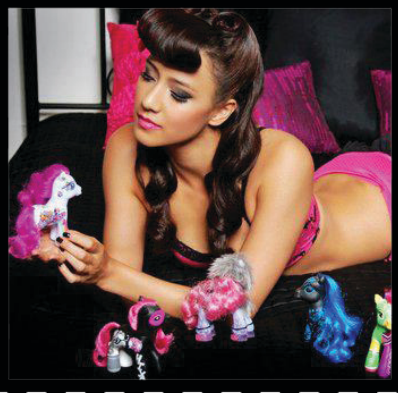
**Milynn:** I get a free pass on dying right? Then the inside of a black hole. I desperately want to know what the ballz is inside of one of those things…or if they lead to somewhere.

**Q:** If you were a spacecraft which one would you be?

**Milynn:** The Tardis, because it can travel through space AND time. Also…bigger on the inside.

**Q:** If you could play any part in any sci-fi / space film or TV show, past, present or future, what would it be and why?

**Milynn:** Leeloo. Why? Multipass.


Photographic rendering of Bigelow Aersospace's BEAM inflatable module docked to the ISS. *Image: Bigelow Aerospace*


# Bigelow's promise: More space at less cost with inflatable space habitats

*By Lloyd Campbell*

We've all seen or played in one of those inflatable bounce houses at a carnival or a friend's birthday party. Now just imagine a bounce house that you can live inside of in outer space.

While much more advanced than a bounce house, that's what Bigelow Aerospace is pursuing. They are designing and building inflatable habitats that can be used in outer space, providing work and living areas while protecting the occupants from the harsh environment of space.

When you look at the International Space Station modules, they are hard shelled, looking very sturdy and strong, so the idea of something that inflates to become a module that humans can inhabit seems very farfetched, but not to Bigelow Aerospace founder Robert Bigelow.

The idea of inflatable spacecraft is not exactly new. In 1958, the newly formed National Aeronautics and Space Administration, NASA, first started a project to design and build such a spacecraft.

The Echo-1 satellite was launched on August 12, 1960 aboard a Thor-Delta Launch vehicle inside a launch canister that was only 3 feet in diameter. The satellite's skin was comprised of 31,416 square feet of Mylar, which was only 0.0127 mm thick. To put that into perspective, a human hair is approximately 0.06 to 0.10 mm thick. The Mylar was covered with a thin aluminum coating that allowed signals to bounce off the satellite when sent to it. When inflated on orbit, it had a diameter of over 100 feet, higher than a 10 story building.

It deployed at 1,000 miles high and was easily seen with the naked eye here on Earth. It lasted 8 years in orbit before finally reentering the atmosphere and burning up.

While Echo-1 was a long way from being a spacecraft

Artist rendering of the The Bigelow Expandable Activity Module (BEAM) which will be sent to the ISS in 2015. *Image: Bigelow Aerospace*

that humans could inhabit, it was basically a large balloon with no life support systems, no radiation protection, no facilities to work or sleep in, but it proved that inflatable spacecraft were indeed feasible.

Inflatable spacecraft were not looked into again until 1992 when NASA was tasked with developing a plan for a manned mission to Mars. Unfortunately the Mars Mission planning was cancelled and once again, inflatable habitats were also.

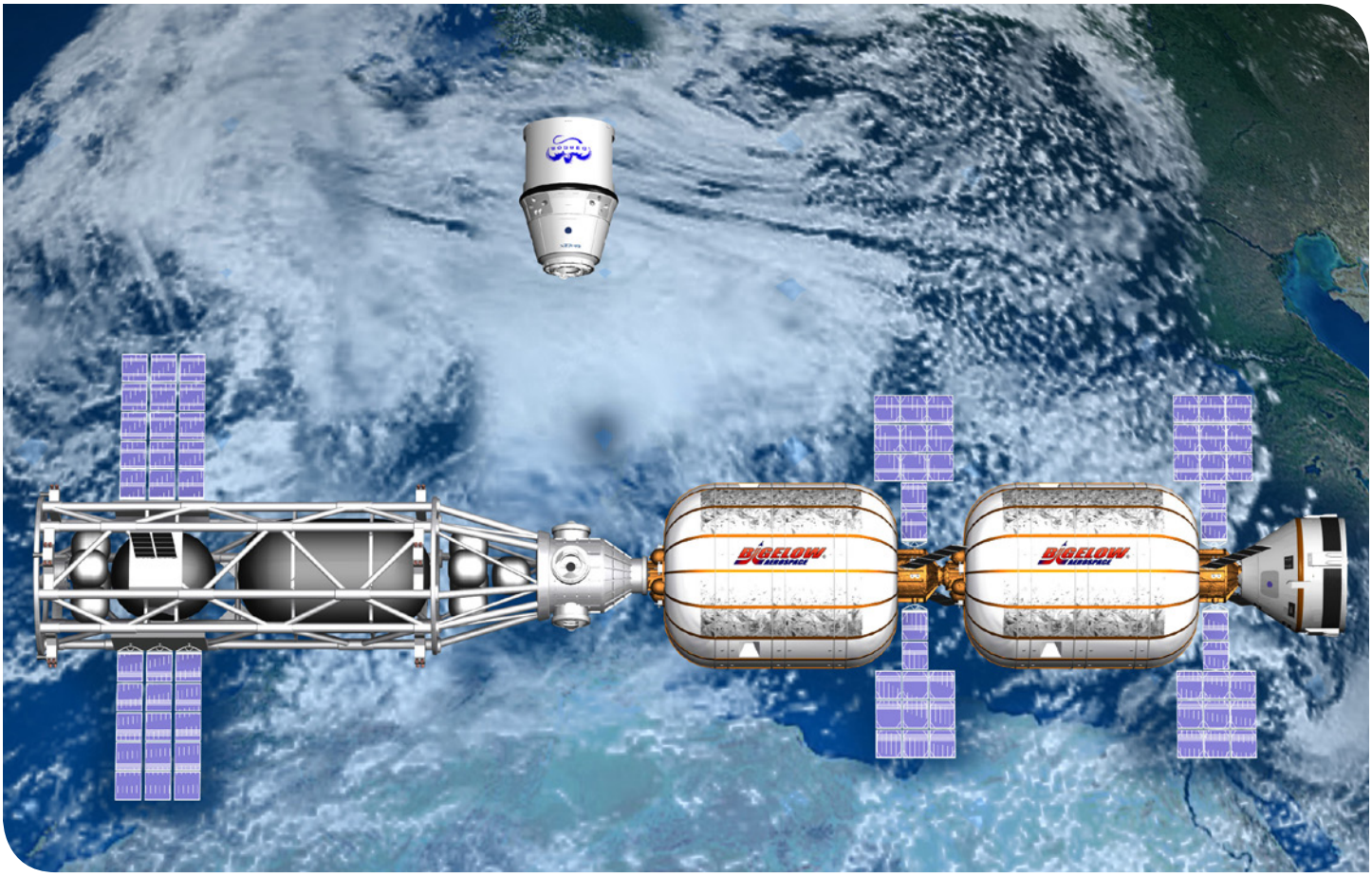
In 1997 when planning was well underway for the International Space Station (ISS), the idea was revived as a possibility for use on the ISS. NASA had designed and built a test Transhab module before the inflatable habitat initiative was cancelled in 2000.

Robert Bigelow heard of the latest cancellation of the inflatable habitats by NASA and persuaded NASA to grant him exclusive licensing to the technology and formed Bigelow Aerospace. The company is based in the desert area of North Las Vegas, an area that most people would not think of when they think of spacecraft development.


The Echo 2, a rigidized inflatable balloon, was launched into orbit by in 1964. Men and a car are seen at the base of it. *Photo: NASA*

Despite having the technology licensed from NASA, the company had to re-develop a lot of the current technologies before they could launch a test habitat. The end result, in only five years, was the launch of the Genesis I test habitat on July 12. 2006. Genesis I is still in service today providing important test data back to mission flight controllers at Bigelow's Las Vegas facility.

Another test article, Genesis II, launched just one year later, and is also still operational. Both spacecraft have six inch multi-layer skins




Artist rendering of a SpaceX Dragon on approach to a Bigelow space station. *Image: Bigelow Aerospace*

and measure 14.43 feet long by 8.33 ft. in diameter which results in 11.5 cubic meters of useable volume inside. Before being expanded, the diameter of the spacecraft is just 4.24 feet in diameter which saves a lot of volume in the launch vehicle payload faring.

The vehicles orbit the earth every 96 minutes, 350 miles up, travelling at nearly 17,000 MPH. You can track Genesis I at www.satview.org/?sat_id=29252U and Genesis II at www.satview.org/?sat_id=31789U.

On January 16, 2013, with the Genesis test articles continuing to prove the technology and reliability of Bigelow's designs, NASA awarded a $17.8 million contract to Bigelow Aerospace to provide a Bigelow Expandable Activity Module (BEAM) for a two-year technology demonstration.

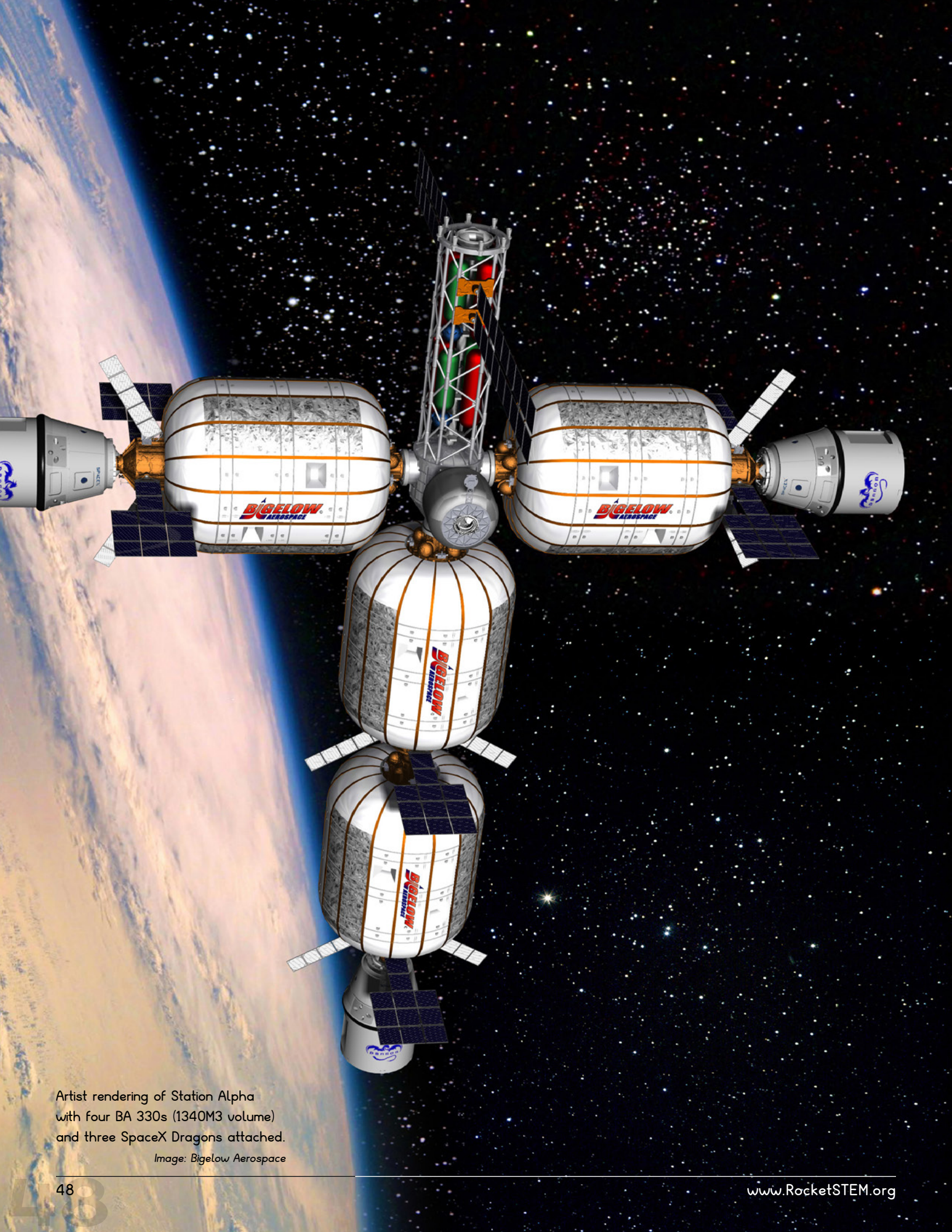
BEAM is scheduled to launch aboard a Falcon 9 rocket in the unpressurized cargo area (referred to as the trunk) of the Dragon capsule. Upon arrival at the ISS, the crew will remove the BEAM habitat from the Dragon's trunk and dock it to the aft port of Node 3. After successful docking the crew will initiate the deployment sequence and Beam will expand to 13 feet long by 10.5 feet in diameter. Once fully deployed, one of the crew will enter the BEAM, becoming the first astronaut to enter an inflatable habitat.

Bigelow Aerospace founder Robert Bigelow

During the two-year test period, ISS crew members, Mission Controllers on the ground, and instruments embedded in the module will monitor BEAM's performance. Data recorded will include its structural integrity and leak rate, radiation levels, and temperature changes compared with traditional aluminum modules.

Due to the lack of a metal skin, the Bigelow habitats should actually provide better radiation shielding than the ISS modules currently in use.

Following BEAM will be the BA 330 modules. These are




Artist rendering of Station Alpha with four BA 330s (1340M3 volume) and three SpaceX Dragons attached.

*Image: Bigelow Aerospace*

massive habitats at 45 feet in length and over 22 feet in diameter. They will provide 330 cubic meters (almost 11,760 cubic feet) of useable interior space. To put that into perspective, a 12 ft. by 12 ft. bedroom with 8 foot high ceilings is only 1,152 cubic feet of space. The Harmony module on the ISS provides just 2,666 cubic feet of living space.

One BA 330 will be able to support a crew of 6 and the modules can be connected to form a larger complex. The BA 330 has an innovative Micrometeorite and Orbital Debris Shield, which in testing by Bigelow has proven superior to the Aluminum skinned modules currently in use on the ISS. Each BA 330 will have two propulsion systems for maneuvers and orbital boosts and independent avionics systems to support those maneuvers. Electrical power will be supplied by solar arrays and storage batteries. Each BA 300 will have its own Environment Control and Life Support System including lavatory and hygiene facilities. And for a room with a view, the BA 330 sports 4 large windows which are UV coated for protection.

The uses for such a large habitat range from a space station, to a hydroponics farm growing some of the food for the crew, to medical research, even a storage facility where crews venturing out into deep space could dock and resupply before starting, or during their voyage.

Other models of the BA 330 are being developed also. The BA 330-DS is modified to be used in deep space, such as in lunar orbit or in one of the Lagrange Points, where gravitational forces act on a spacecraft in such a way to allow it to orbit with the celestial body they are near. This effectively neutralizes the movement of the spacecraft, allowing it to reside in the same point indefinitely. The main difference between the Deep Space and regular BA 330 is additional radiation shielding.

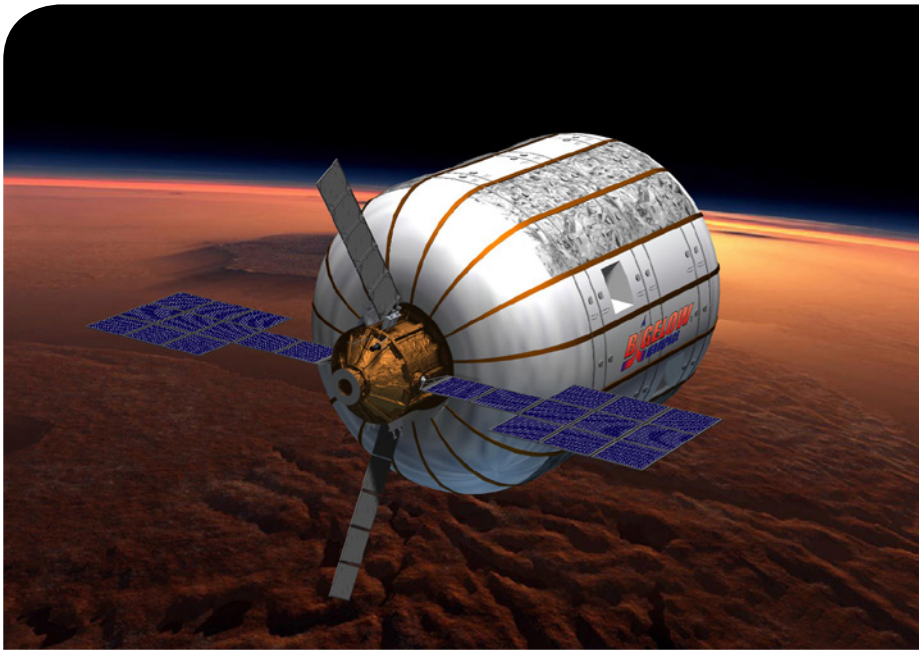
Another version known as the BA 330-MDS is configured to allow landing on another celestial body, such as the Moon. It would come with propulsion systems which would allow it to land on the surface and modifications to the structure to allow it to reside on the surface. With its large size, the BA 330-MDs would essentially be its own Lunar Base once landed on the surface of the Moon.

Robert Bigelow is not stopping there either. Bigelow Aerospace is designing an even larger habitat named Olympus. Due to its massive interior volume of 2,250 cubic meters (79,458 cubic feet) , it would need to be launched on NASA's Space Launch System (SLS), or perhaps the SpaceX Falcon 9 Heavy which is also in the design and construction phase.

Similar in design to the BA 330 but on a much larger scale, it could accommodate a crew of 24 or more. A modified version of this massive habitat could allow smaller spacecraft to enter it for transport, or so that astronauts could work on them, essentially a hangar in space. Due to the massive size, the Olympus habitats would not be built in Las Vegas. They would need to be built on a waterway, most likely close to the launch facility where they would launch from.

Also in the planning stages is an effort to launch their own astronauts or perhaps even paid tourists into space. But unlike all other U.S. manned launches coming from Cape Kennedy / Cape Canveral, Bigelow is looking at the recently expanded launch site at Wallops Island, Virginia. Recently, Director of D.C. Operations Mike Gold expressed interest in that facility as it would have less traffic then the Florida facilities allowing more flexibility and frequency of launches. A proposal to NASA will hopefully be submitted soon.

The future of space exploration seems to indeed include expandable modules, and Bigelow Aerospace is leading the way. NASA is very interested in them once again, and Robert Bigelow is so sure of their success that he has invested over a quarter of a billion dollars into this venture already. Maybe someday you will be able to catch a ride aboard a Dragon or Dream Chaser spacecraft and head to one of his habitats in outer space. But for now, just think about the amazing future that lies ahead the next time you see one of those bounce houses.




An artist rendering of a BA 330 inflatable space habitat in orbit above Mars. The BA 330 contains 330 cubic meters of volume inside of it.

*Image: Bigelow Aerospace*

## Information sources: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- www.nasaspaceflight.com/2014/02/affordable-habitats-more-buck-rogers-less-money-bigelow/

# A city in the sky:
## A cheaper space station from Bigelow

### Vocabulary

- **BA-2100:** A Bigelow module. Volume: 2,100 $m^3$. Weight: 100 mT. Crew: 16, Cost: $500M.
- **BA-330:** A Bigelow module. Volume: 330 $m^3$. Weight: 25 mT. Crew: 6. Cost: $125M.
- **Falcon Heavy:** An expendable launch vehicle from SpaceX. Payload: 53 mT. Cost: $150M.
- **Propulsion Bus/Docking Node (PB/DN):** A unit used to reboost the space station due to orbital decay coupled with a module that allows Bigelow modules to be attached together. Weight: 17 mT. Cost: $75M.
- **Space Launch System Block I-A (SLS I-A):** An expendable launch vehicle from NASA. Payload: 105 mT. Cost: $750M.

### Narrative

To live and work and be productive in space, you have to have a place to call home. While the Earth is certainly a great place to go home to (free air! free water! free - well, you get the point), it would become very expensive indeed if every time you knocked off your shift in space you took a ride back to Earth, and then got up the next day to fly back into space again! The obvious answer is to place your home, your city if you will, in space.

Shopping around for what's available to use to build our city, we happily find Bigelow Aerospace, makers of the famous BA-330 and BA-2100 space station habitat modules (the names of the modules denote the pressurized volume of each unit). These inflatable modules go into space, where they, well, you know, inflate. Astronauts then move into what is essentially a balloon in space (aren't all space modules really just that?). Ah, but what a balloon!

Crew capsules can dock at either end, and power is derived from solar panels, while excess heat is dumped into the biting cold of space using radiators. It even has windows! Home sweet home, indeed.

### Analysis

To launch these excellent habitat modules into space, we obviously need a launch vehicle. Once again, shopping around for what's available to use to launch our city we find two Expendable Launch Vehicles (ELV). These rockets haven't been built yet, but so long as funding continues they will be one day. The two ELVs are the SLS I-A and the Falcon Heavy.

Since the SLS I-A ELV can carry 105 mT into Low Earth Orbit (LEO), and one BA-2100 weighs 100 mT, it can carry only one unit at a time. We will call this the "BA-2100 Stack."

The Falcon Heavy ELV can lift 53 mT to LEO, and each BA-330 weighs 25 mT, so it can carry 2 units at a time (assuming, of course, that it could fit in a payload shroud). We will call this the "BA-330 Stack." The PB/DNs each weigh 17 mT, so 3 units will fly on the Falcon Heavy ELV to LEO. This will be called the "PB/DN Stack."

**BA-2100 Stack**

- Cost: (1) SLS IA + (1) BA-2100 = $750M + $500M = $1,250M
- Weight: (1) BA-2100 = (1) 100 mT = 100 mT
- Volume: (1) 2,100 $m^3$ = 2,100 $m^3$
- Crew: (1) 16 = 16 Astronauts

**BA-330 Stack**

- (1) Falcon Heavy + (2) BA-2100 = $150M + (2) $125M = $400M
- Weight: (2) BA-330 = (2) 25 mT = 50 mT
- Volume: (2) 330 $m^3$ = 660 $m^3$
- Crew: (2) 6 = 12 Astronauts

**PB/DN Stack**

- (1) Falcon Heavy + (3) PB/DN = $150M + (3) $75M = $375M
- Weight: (3) 17 mT = 51 mT

So let's build us a city in space, shall we? Hey, if the high school students at The Learning Community Charter School (www.tlcnm.net) in Albuquerque NM can have fun with this, then so can we.

### Example

The folks at Bigelow Aerospace have made it easy for us: they've already designed a very nice space station! It's called the "Hercules Resupply Depot," but we'll just call it "Home." Thanks, Bigelow!

*For a more in-depth treatment of this high school project by Joe Maness & Rich Holtzin visit www.stemfortheclassroom.com.*


As you can see from the poster, we'll need three BA-2100s, six BA-330s, and three PB/DNs to complete the design. We can therefore calculate how many "stacks" we'll need:

**(3) BA-2100 = (3) BA-2100 Stacks**

- (3) $1,250M = $3,750M
- (3) 100 mT = 300 mT
- (3) 2,100 m3 = 6,300 $m^3$
- (3) 16 Crew = 48 Crew

**(6) BA-330 = (3) BA-330 Stacks**

- (3) $400M = $1,200M
- (6) 25 mT = 150 mT
- (6) 330 $m^3$ = 1,980 $m^3$
- (6) 6 Crew = 36 Crew

**(3) PB/DN = (1) PB/DN Stack**

- (1) $375M
- (3) 17 mT = 51 mT

Adding everything up we get:

- Total Cost: $5,325M
- Total Weight: 501 mT
- Total Volume: 8,280 $m^3$
- Total Crew: 84 Astronauts

Notice that our volume is close to the 8,300 cubic meters advertised in the Hercules image.

## Conclusion

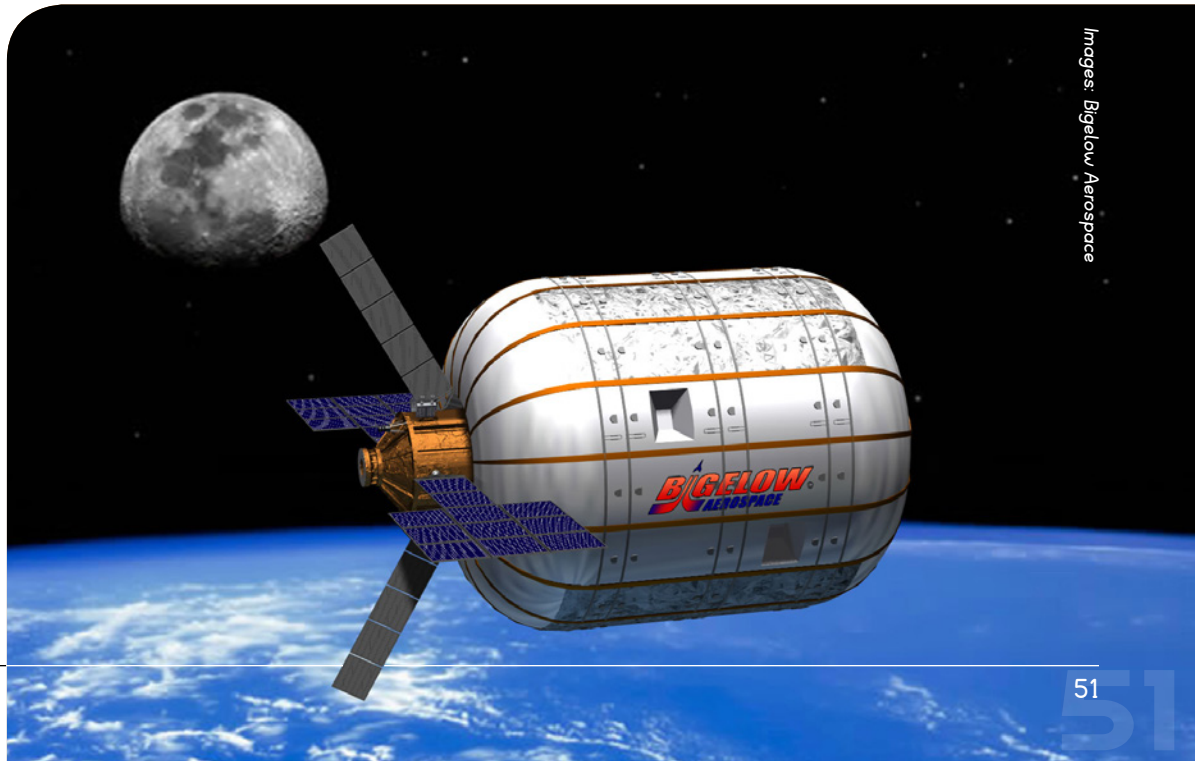
Currently, the International Space Station (I.S.S.) is orbiting the Earth, but will eventually be retired. There really is no comparison, however, in their home and ours:

| | COST | WEIGHT | VOLUME | CREW |
|---|---|---|---|---|
| HERCULES: | $5,325M | 501 mT | 8,280 $m^3$ | 84 |
| I.S.S.: | $150,000M | 450 mT | 837 $m^3$ | 6 |

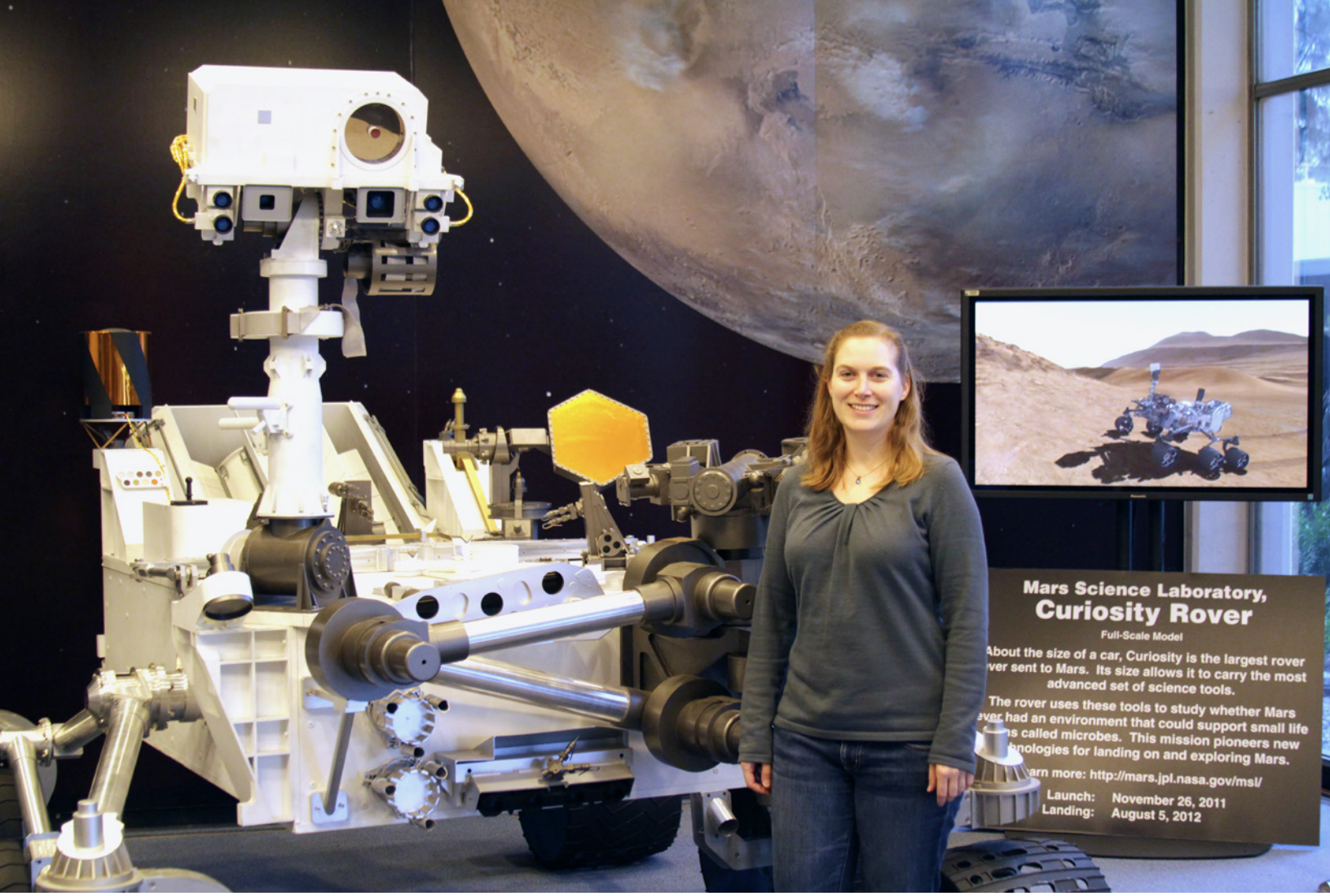
While the two space station weights are nearly equal, the total volume is nearly ten (10) times the International Space Station with 14 times as many crew, all for 1/30th the cost. It's keeping up with the Jones' in reverse!

Maybe when the I.S.S. retires in the near future the international community can move on up to a bigger and better place that's a wee bit more affordable, si?

*Bigelow's inflatatable modules may one day make it affordable for corporations to build their own stations.*




Images: Bigelow Aerospace




Kim Lichtenberg has been 'working on Mars' as a student and as a scientist and engineer for three Martian rovers. *Photo: Brenden Clark*

# Kim Lichtenberg spends her days sampling Martian soil and rocks

*Interview by Ken Kremer*

*RocketSTEM spoke with Dr. Kimberly Lichtenberg, a scientist and engineer who works on NASA's Mars rover missions at NASA's Jet Propulsion Laboratory (JPL), Pasadena, Calif., in conjunction with our "Women in Aerospace" series.*

*We spoke about her career at NASA, role models, education and how she became interested in space exploration. Indeed she's been in love with space virtually her entire life. Her father, Byron Lichtenberg was a Space Shuttle astronaut and an inspiration.*

*Kim's current project is NASA's newest Mars surface mission, the Curiosity Mars Science Laboratory (MSL) rover which touched down on the Red Planet on Aug. 6, 2012.*

**Q:** People are very interested in what you're doing at NASA and on the Mars missions, in particular as a woman in aerospace. I'd like to start a little bit on your background. What got you excited and motivated about space and to study science and engineering?

**Kim:** I'm actually a little bit of both. My undergrad is in engineering. My Master's and Doctorate are in science. I have kind of one foot in one area and one foot in the other.

**Q:** Tell us please about where did you grow up and your father?

**Kim:** I grew up in New England. I spent my formative years up through college between Massachusetts and Virginia, along the Mid-Atlantic East Coast up inside the New England area. As I mentioned, my dad, Byron Lichtenberg, was an astronaut. He went up on STS-9 and STS-45 in 1983 and 1992, respectively.

**Q:** Who were your role models growing up?

**Kim:** I had a bunch of female role models in high school in general because I went to an all-girls high school. But they were not necessarily specifically in the sciences and engineering.

I actually particularly like Queen Latifah. It sounds really funny but she is just ... She just seems like a good, strong overall female role model. She's a rapper and an actress.

**Q:** I would never have guessed that. Queen Latifah. Why is that?

**Kim:** She seems really confident and very sure of herself but not in an overbearing way, if that makes sense.

**Q:** How about any other astronauts?

**Kim:** I think in general astronauts as a whole were definitely there. But in particular Sally Ride is just fantastic.

Valentina Tereshkova is possibly even more important than Sally Ride because I actually got to meet her when I was in high school. That was pretty amazing.

**Q:** Met her in high school. Was that because of your dad or some other reason?

**Kim:** My dad took me as a tagalong to a conference he went to in DC. I got to meet her and talk to her. She spoke English, not all that well. But I was able to communicate with her. She's a formidable woman!

**Q:** What motivated your interest in science and Mars?

**Kim:** One way I got interested in it was thorough my dad. I grew up being immersed in the space program. The other way ... I've always been interested in science and engineering but it wasn't actually until college that I really got interested in planetary science. I spent a summer with the NASA astrobiology Institute. It's a summer program for undergrads and graduate students. There are a couple of different NASA summer programs. That was the first summer I heard about Europa, which is one of the moons of Jupiter.

At Washington University, Ray Arvidson was my PhD advisor. Ray works on numerous NASA Mars missions. I had a great time in graduate school. As it turns out, I really loved working on Mars. He is a fantastic scientist. He also thinks a little bit like an engineer as well which is unusual for a scientist.

**Q:** For Ray, you worked on the Spirit and Opportunity MER missions?

**Kim:** I worked on both. I was more heavily involved in Spirit. And especially heavily involved in the Spirit extrication effort when Spirit was stuck.

Martian landscape scene with rows of striated rocks in the foreground and spectacular Mount Sharp on the horizon. NASA's Curiosity Mars rover paused mid drive at the Junda outcrop to snap the component images for this colorized navcam camera photomosaic on Sol 548 (Feb. 19. 2014) and then continued traveling southwards towards mountain base.

*Image: NASA/JPL-Caltech/Marco Di Lorenzo/Ken Kremer*

**Q:** That's very interesting and a very sad outcome on Spirit extrication. Can you describe that?

**Kim:** Yeah. It was entirely possible that if we had just a few more weeks before when winter set in, we might have actually made it out. We just needed more time. We didn't have it.

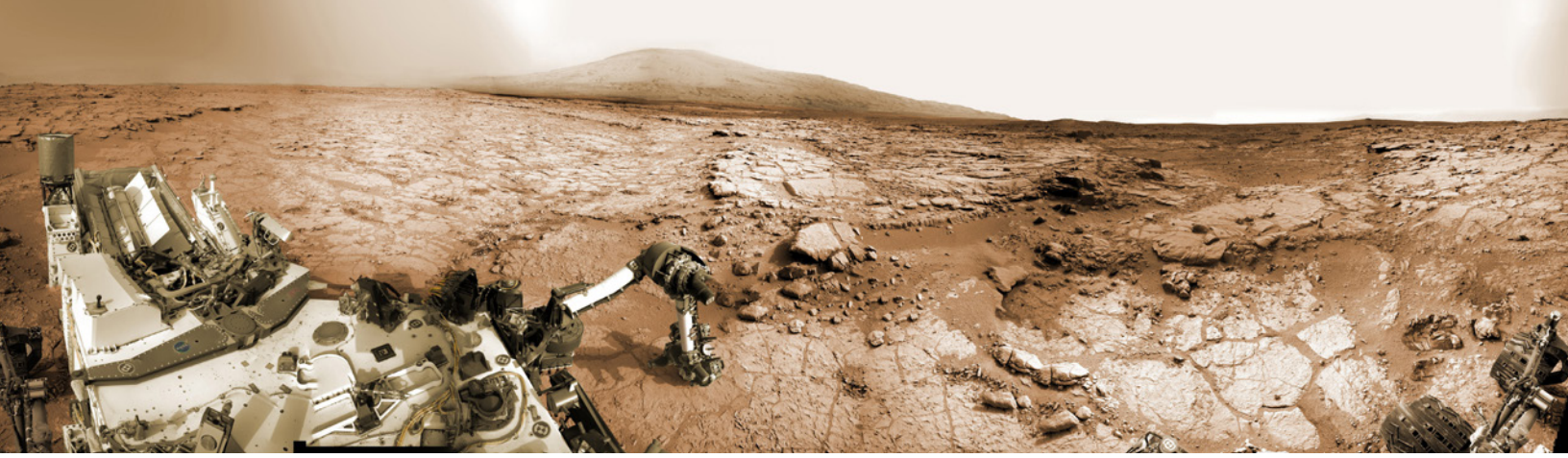
What we were actually trying to do is get Spirit to a south-facing slope. Because during the winter, that would maximize the solar radiation on the panel to get more power. Since we weren't on a south-facing slope, we didn't get as much energy. Basically, the power started to decrease enough that she didn't have enough power to communicate with earth. Then when we came out of winter, she just never woke up again. We're not exactly sure what happened but probably something thermal-related.

**Q:** Now you're working on MSL. And the team certainly has some lessons learned from that Spirit episode for how you would operate Curiosity?

**Kim:** Yes, you can't necessarily determine what the terrain's going to be like, just from looking at what the surface looks like. To some extent you can. Obviously if there's bedrock and you can see it, you know that's going to be pretty easy to drive on. But if you're driving on some sandy materials, this material has been undisturbed, other than by wind for a very, very, very long time on Mars. It's had a lot of dust accumulation which it can hide with under the surface.

Probably the biggest lesson that we've learned from MER and that we are definitely taking to heart on MSL will be to be very careful when we are driving and see the dunes coming up. We won't necessarily plunge right in. But maybe take a toe dip and see how the Rovers and the system is going to react.

**Q:** Right, especially when you get closer to Mount Sharp and you have to cross that dune field.



Curiosity discovered a habitable zone, shown in this context mosaic view of the Yellowknife Bay basin taken on Sol 169. The robotic arm is pressing down on the surface with Mount Sharp in the distance. *Image: NASA/JPL-Caltech/Ken Kremer/Marco Di Lorenzo*

**Kim:** Exactly.

**Q:** How and when did you get to work for JPL?

**Kim:** Through my graduate work I was able to realize that mission operations was what I really wanted to do. With that in mind, when I was coming close to graduating I began putting the word out at JPL. I got super lucky. They were starting to look for operations personnel for MSL at that time. I got hired in 2010 as a mission operations engineer.

**Q:** What were your responsibilities as MSL operations engineer?

**Kim:** I was focused on the uplink process, uplink from Earth to the Rover. Really it was a tactical planning cycle. You start off with basically ... You have a day on the Rover that you want to have the Rover do something with. Most of the scientists will put forth ideas. They'll propose a whole bunch of different stuff.

We basically throw it all into one plan and hash out with the scientists what's going to fit and what's not going to fit. That part of the process was the part that I was most heavily involved in. It's figuring out how much we can fit into the Rover in a day and how much data can we get down. Is it going to be enough to plan for the next sol?

**Q:** And at some point after landing you switched from mission operations to specifically working on the Sample Analysis at Mars (SAM) instrument that analyzes the soil and rock samples collected by the drill?

**Kim:** Yes I switched in January 2013. I'm loving it so far.

**Q:** Describe your new position as the instrument system engineer for SAM?

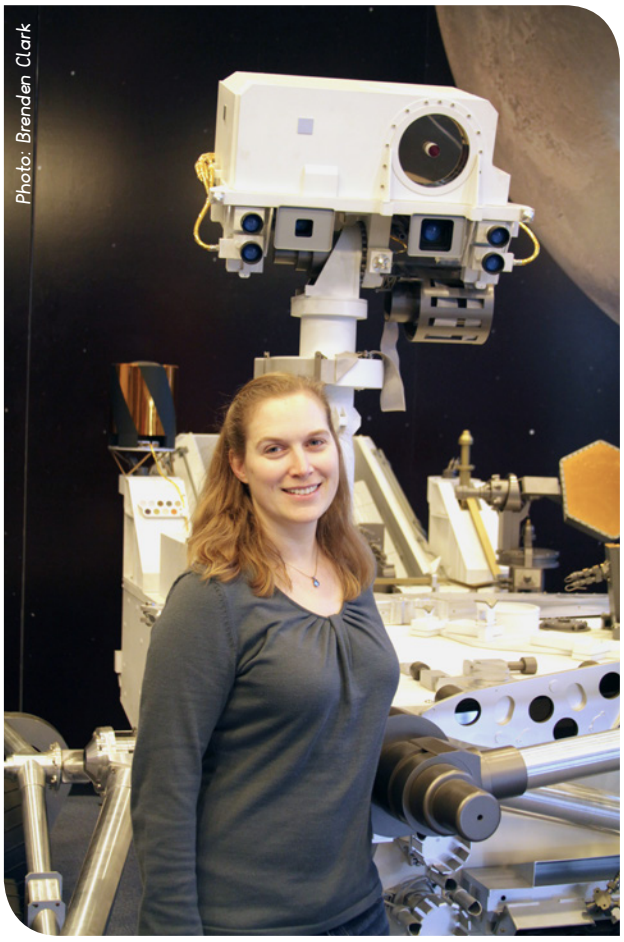


Photo: Brenden Clark

Space runs in the family: Kim's father was an astronaut.

**Kim:** Each of the instruments has an instrument system engineer who works for JPL. They are kind of the technical liaison between the instrument teams which are usually not at JPL and the project management. The prior SAM instrument engineer had gotten a fantastic job offer on another project and they were looking for a replacement. I got the job.

**Q:** Tell us more about what's involved in being the SAM instrument engineer. Are you the lead engineer?

**Kim:** I'm the lead engineer. Basically I make sure that if there's anything that the JPL project management needs to communicate to the SAM team who are at NASA Goddard I make sure that that information flows and gets to the right people. Also on the other side on the same team if there's something that they need or want from the JPL project management, I make sure that they get the information they need.

I work with both the SAM team very intimately and the MSL project management. That's on the telecommunication side. On the technical side, we have models of the Rover here on Earth that we do testing on for any new flight software or new things that we want to try. If there's anything that's

SAM related that we want to test before it goes up onto the Rover.

**Q:** How about drilling operations to collect the samples for SAM?

**Kim:** Yes. It's part of my job planning for drilling such as at John Klein and Cumberland. We have to plan one day at a time if that's going to happen. We might discover something on the downlink that would push that off or move it.

**Q:** When does your responsibly begin with the drill sample?

**Kim:** It starts with using SAM to analyze the drill samples. We have a team of people called rover planners who are the ones that conduct all the mobility, all the sampling and also the drop-off to the SAM instrument.

There's a handshaking that has to happen between the sample and the SAM instrument.

**Q:** How has SAM operated so far at the sites examined so far, for example Rocknest and John Klein? What's your assessment?

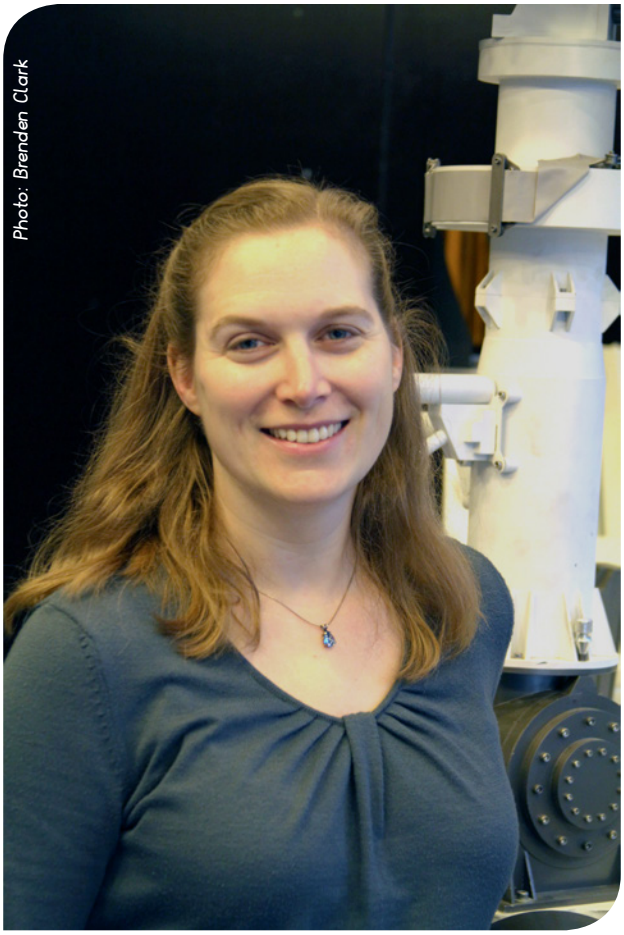


Photo: Brenden Clark

Kim now works as the engineer for the MSL SAM instrument.

**Kim:** Fantastically. In terms of how the instrument has worked on the engineering level, SAM is absolutely amazing. It is such a complicated instrument. It's actually three instruments in one. In order to get the best science from the instrument, we've left it so that it's very tweakable. Actually we run scripts on this. It's actually more like code. It's writing a program each time we want to do any analysis with it. The code itself turns on heaters, can pump out the instrument. It's kind of infinitely customizable.

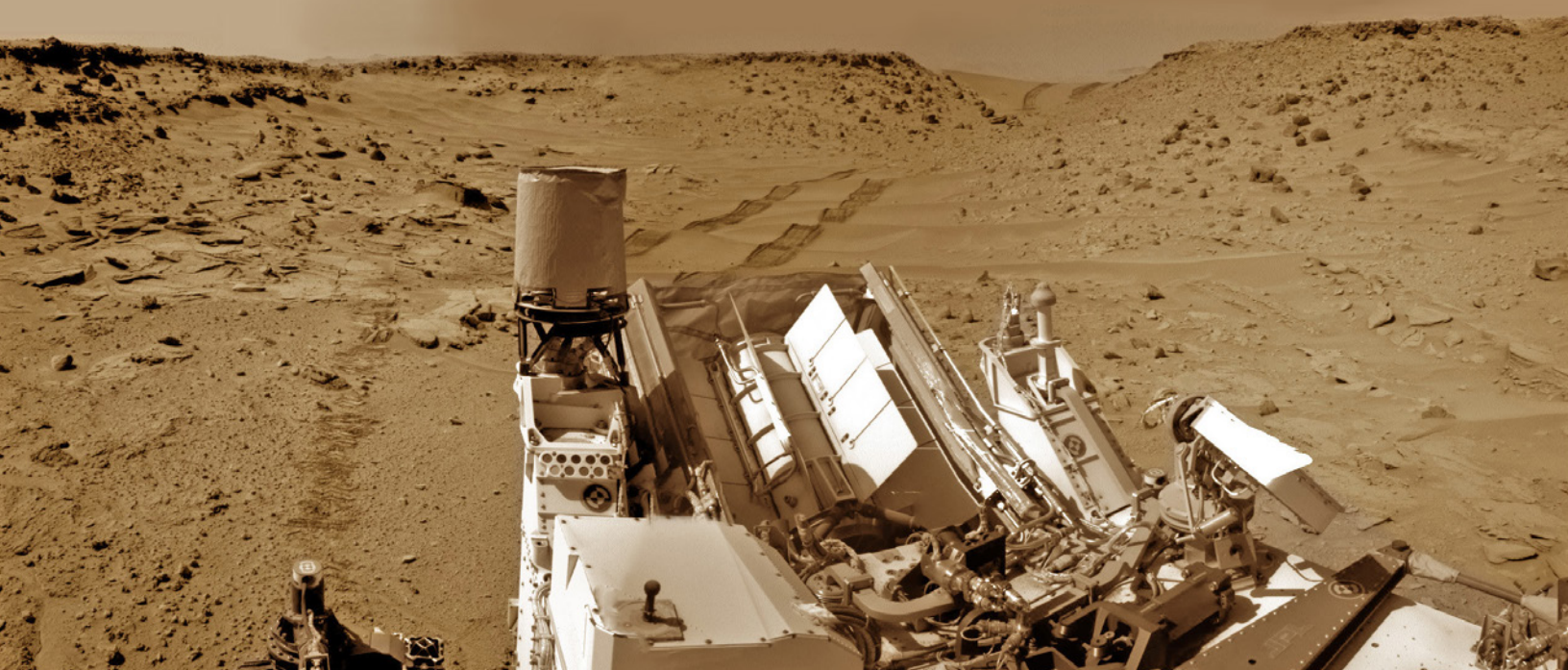
We'll be busy over the rest of the prime mission. Goddard has a test version of SAM that they have set up in a thermal vacuum chamber.

They run all their scripts on that ahead of time to make sure that all the limits are set correctly and that the script is safe to run on the surface. But you can't model everything. Sometimes things work a little differently on the surface than they do on the test pad at Goddard.

**Q:** I guess to finish up, please tell me how happy or proud are you to work on this mission?

**Kim:** Oh my goodness. I can't even put any words to that adequately. I am thrilled. I am so happy and so proud to be working on this mission. There's really nothing else I'd rather be doing.

Curiosity looks back eastward to 'Dingo Gap' sand dune inside Gale Crater. After crossing over the dune on Feb. 9, 2014 the rover drove into the 'Moonlight Valley'. The parallel rover wheel tracks are 9 feet (2.7 meters) apart. *Image: NASA/JPL/Ken Kremer/Marco Di Lorenzo*



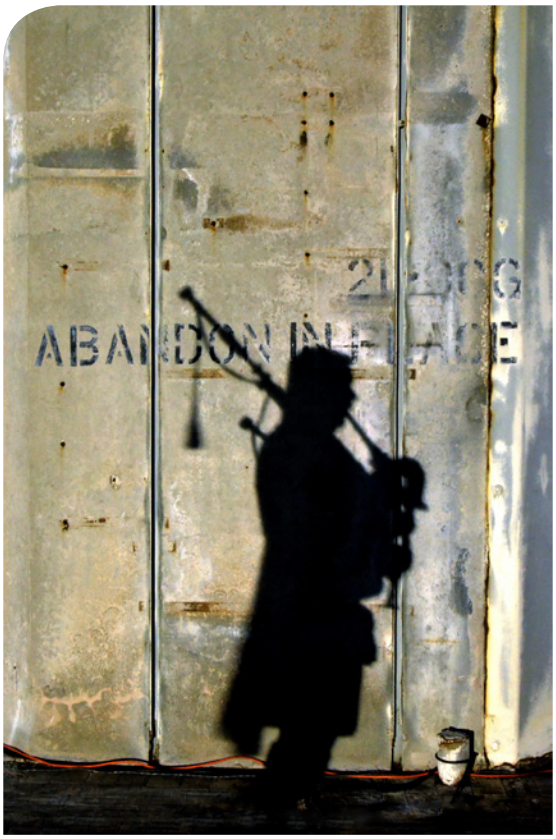
# Abandon in place

## Betty Grissom's last visit to Apollo 1 memorial

*By Mary Kanian*

Is Gus Grissom's widow herself about to "abandon in place" the memorial vigil she has maintained over the last 48 years since the fiery death suffered by her husband, Astronaut Commander Virgil "Gus" Grissom and fellow astronauts Roger Chaffee and Ed White back in 1967 at Pad 34 Cape Canaveral Air Force Station (CCAFS)?

They were the first human martyrs of our pioneering efforts at manned space flight, occurring just as our space program was progressing toward larger missions and more complex vehicles. The flash fire that so quickly took their lives was a reminder that, despite all precautions taken to ensure safety, things can go horribly wrong. Their line of work is one of high risk, which they knew full well yet they chose to "push the envelope" as far as it was possible for them to do. They constantly reaffirmed their commitment and our nation's commitment to the program, with Grissom himself stating "If we die, we want people to accept it…..we hope if anything happens to us, it will not delay the program. The conquest of space is worth the risk of life."



Silohuette of a bagpiper against the LC-34 concrete launch pedestal. *Photo: Julian Leek/JNN*

In the aftermath of the accident, there were doubts, suspicions, recriminations and bitterness expressed over what happened to the three men, but the program moved on with full support of the families. And they, in turn, were there for the families after the stunning loss of the shuttle Challenger and its crew in 1986 during launch and again in 2003 following the loss of a second shuttle, Columbia, which took another 7 lives when the orbiter succumbed to damage sustained during launch and broke up on re-entry. At that time, Betty Grissom stated, "I also hope that people of all nations will put aside our differences today in a moment of silence and say something special in their own way for each of these of these astronauts and their families today."

At this year's memorial, it was announced in an Air Force press release that this, the 48th annual observance of the Apollo I accident, would be Mrs. Grissom's last. Her health has been in decline in recent years and this observance saw her wheeled in by wheelchair, reflecting the toll that accumulating years have finally taken. Indeed, as the sign on Pad 34 (CCAFS) crudely and simply states "ABANDON IN PLACE"...a military directive meaning "leave as is…make no changes" and serves as a troubling metaphor for the disregard which is given to far too many people, places and things of great historical significance in this country.

How long is "long enough" to memorialize the sacrifices made by the dead. How long need a building or a battlefield be preserved to honor its role as the site of an historic event. Progress often acts as a two-edged sword, capable of slicing away the staid old practices of the past to find a new path…. a new way of thinking and getting things done better, faster, cheaper. It is a hallmark of this country and a key to its phenomenal success. In our haste to establish "a new order" and found our new nation, we nearly lost to decay and

After the Apollo 1 fire. Launch Complex 34 was subsequently used only for the launch of Apollo 7 and later dismantled down to the concrete launch pedestal. *Photo: Julian Leek/JNN*

Gus Grisson meets his family back at Cape Canaveral after the GT-3 mission.

*Photo: NASA via Retro Space Images*

Betty Grissom at the 2014 memorial for Apollo 1.

*Photo: Julian Leek/JNN*

neglect the homes of our founding fathers, George Washington and Thomas Jefferson. The other edge of the sword is our willingness to challenge the ways of the old world and build a country which declared itself to be founded "by the People, for the People and of the People" based on guaranteeing its citizens the right to "Life, Liberty and the Pursuit of Happiness". Its purpose was to protect the liberties and rights that we hold dear and to ensure Equality and Justice for all. Thus it became vital that we protect the physical existence of our founding documents, our historical buildings, halls of public record and museums, places of worship and parks to protect our natural wonders. This is what forms the character of the people of this great nation and ourselves as individuals. What we do not value, we do not protect and preserve; it becomes subject to being lost and forgotten, perhaps relegated to myth, like the Knights of the Round Table.

Sadly, in recent years, attendance to this memorial dropped off and scant attention given in the press. Only a single representative of the press was in evidence last year. Is this a general reflection of a lack of interest in our efforts at space exploration? Or is it the passing of generations and a divide of time and distance that requires us to move on with briefer and briefer glances back at these historic losses and achievements. Who will come to honor these sacrifices after Betty Grissom can no longer maintain her vigil?

Astronauts Gus Grissom. Ed White. and Roger Chaffee in front of Launch Complex 34. The astronauts perished just ten days later in a fire on the launch pad.

*Photo: NASA via Retro Space Images*

# Boeing's CST-100 passes two new milestones in development

The Boeing Company recently announced the completion of more developmental requirements for their Crew Space Transportation 100 (CST-100) spacecraft that includes a software safety test and hardware design review. Passing this phase of testing is considered a milestone for a company that is competing to return flights of astronauts from U.S soil in the coming years.

Boeing's current phase of testing is the Critical Design Review (CDR), which included system analysis of their Launch Vehicle Adapter (LVA) that will connect the CST-100 spacecraft to the rocket that will take it into orbit. This CDR testing was performed to establish the flight stability of the LVA in a wind tunnel and verified that Boeing's design is applicable for production.

CST-100's initial launch vehicle is a United Launch Alliance Atlas V rocket, which played a role in the second phase in its recent testing. Atlas V rocket's emergency detection system also passed an evaluation by showing its ability to communicate with the capsule in the event of an emergency.

"Safety is a key element of the CST-100, from the drawing board to design implementation and beyond," said John Mulholland, vice president and program manager, Boeing Commercial Programs in a statement released by Boeing. "These tests help to validate that the launch vehicle adapter and emergency detection system are fully functioning and able to ensure a safe launch for our future passengers."

More testing is still to come for CST-100 that will include a software review in the spring and a greater


Boeing's CST-100 recently concluded a hardware design review and software safety test. NASA astronaut may one day travel to the ISS via the Boeing spacecraft. *Photo Credit: ULA*

comprehensive integrated CDR this summer. The completion of CST-100 CDR phase is vital to ensure time and budget requirements are being met, and to begin the full-scale manufacturing, assembly, and final integration of a flight-ready spacecraft.

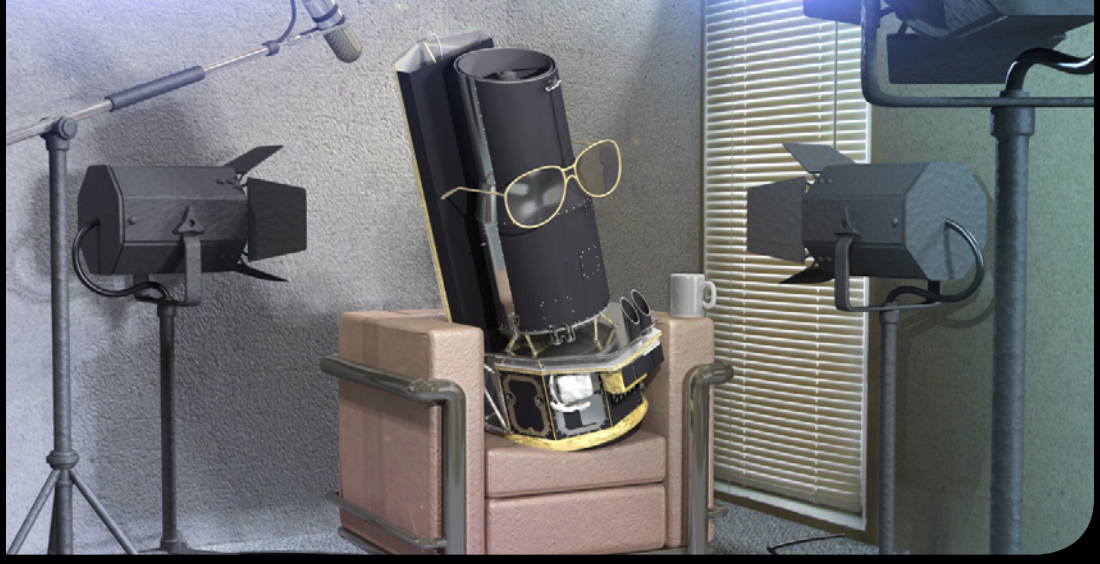
> "Safety is a key element of the CST-100, from the drawing board to design implementation and beyond."
>
> – John Mulholland

Boeing states that they are on target to meet all of their requirements for their agreement with NASA's Commercial Crew Integrated Capability (CCiCap) program that runs through till August of this year. Continued success with NASA's Commercial Crew Development (CCDev) program will bring Boeing closer to their goal of supplying manned missions to the International Space Station.

CCiCap is the third round of NASA's CCDev program that requires companies that participate to show completed end-to-end designs that include spacecraft, launch service, launch system, and ground and mission operation and recovery. This is part of NASA's post-shuttle era mission to work with private companies to develop safe, reliable, and cost efficient transportation systems to supply cargo and crew to low-Earth orbit.

There are three companies currently working towards this goal along with NASA in the CCiCap phase. Sierra Nevada Corporation with the Dream Chaser spacecraft, Space Exploration Technologies (SpaceX) with the Dragon spacecraft, and The Boeing Company with the CST-100 spacecraft.

*Authored by James Tutten, this article originally appeared at www.spaceflightinsider.com.*



Artist's conception of Spitzer giving an interview. *Image: NASA/JPL-Caltech/T. Pyle (SSC)*

# Not a politician; Not a carbonated beverage

*By Ann Marie Cody*

Most blog readers are no doubt familiar with the world of space telescopes. But have you ever gone to your friends and asked them what comes to mind when they hear the word "Spitzer?" Chances are, they will ask if you are referring to a certain politician… Or maybe a carbonated beverage. Now is the time to set them straight! The 10th birthday of the Spitzer Space Telescope has arrived, and we are celebrating the wealth of images that it has brought us over the past decade.

As an astronomer who works on Spitzer data nearly everyday, I love to tell friends and family about the research contributions of different types of space telescopes, from X-ray to infrared. Our team at the Spitzer Science Center (SSC) collaborates on a large project to monitor the fits and growth spurts of baby stars in the open cluster NGC 2264. In fact, fellow astronomer Luisa Rebull introduced this campaign a while back. I love gazing at the colorful nebulosity that makes up the many star-forming regions that Spitzer has observed over the years.

I've got to sheepishly admit, though, that being a research astronomer is not always about looking at pretty pictures. We run a lot of computer code, we break the computer code, and we spend months working on papers. Some of these activities can be frustrating, and I inevitably turn to music on the days when data reduction is not going smoothly, or the results seem outright wrong. I'm not one to collect thousands of songs on an iPod, so instead I turn to YouTube for its variety of musical playlists. And during my year and a half as a postdoctoral researcher at the Spitzer Science Center, I've discovered dozens of inspiring pieces that sometimes just seems to blend in with what I'm working on. As I crank away on infrared data, sometimes I wonder what the telescope would sing or play, if it could (yes, I tend to delight in the absurd).

And then an idea popped into my head - why not go ahead and set a musical arrangement for this venerable space observatory? Around the same time, I discovered the movie making software on my laptop, and a new hobby was born. In honor of the 10th anniversary of the telescope's launch, and all the engineers and scientists who made it possible, I now present a musical and astronomical birthday present to Spitzer! It is an arrangement of the William Tell Overture composed by Rossini. http://www.youtube.com/watch?v=NIceDmBEhBg&feature=youtu.be

…Meanwhile, if your friends still think that Spitzer is a politician, maybe you want to kindly point them to the video.

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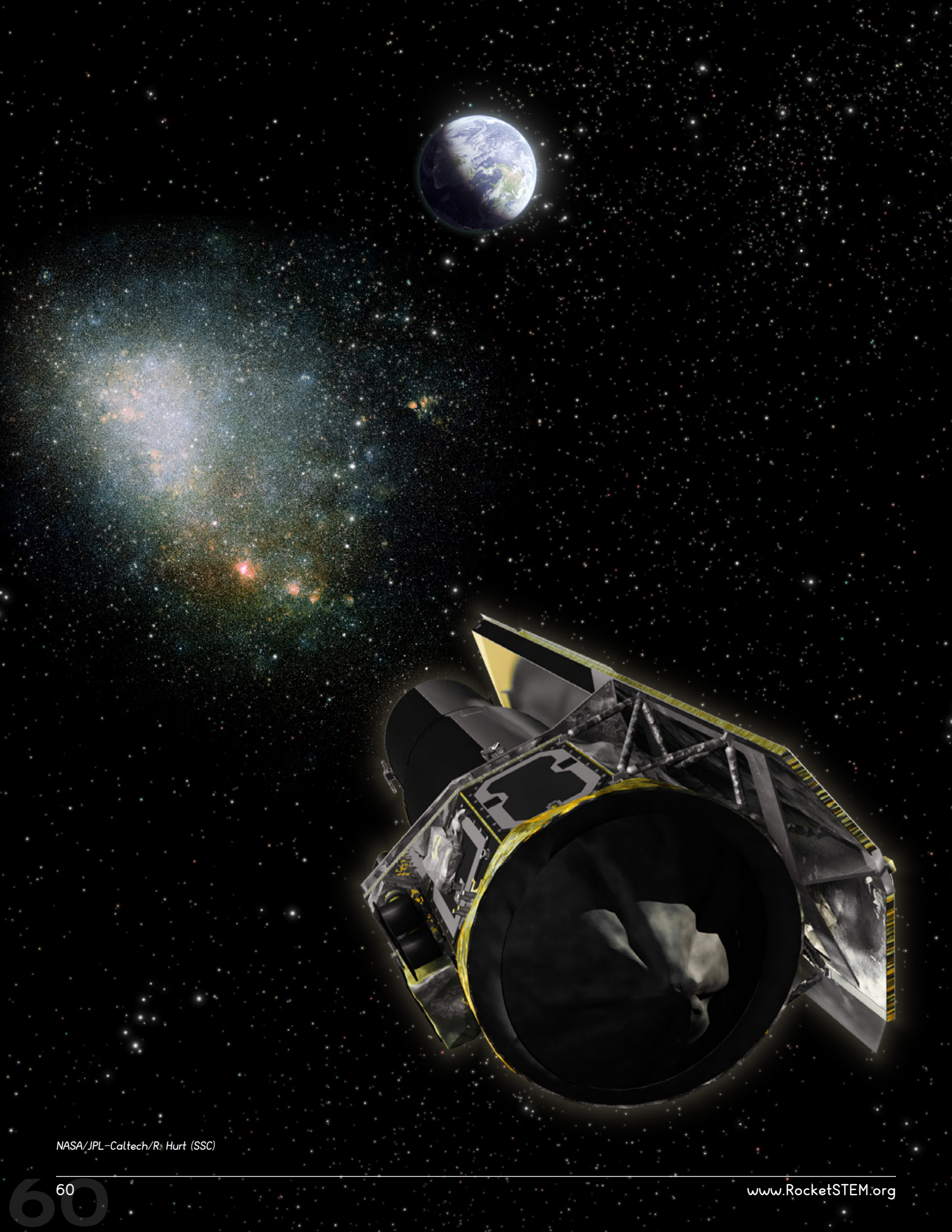
*Cody is a postdoctoral scholar at Caltech, working with the Young Stellar Object Variability group at Spitzer/IPAC on the Coordinated Synoptic Investigation of NGC 2264.*



NASA/JPL-Caltech/R. Hurt (SSC)

# The Spitzer Space Telescope:
# Ten years of viewing the Universe's dark side

*By Ben Evans*

More than ten years have now passed since NASA's fourth "Great Observatory"—the Space Infrared Telescope Facility (SIRFT)—was boosted into orbit from Cape Canaveral Air Force Station, Fla., atop a Delta II rocket. It was intended to complement is three older siblings, the Hubble Space Telescope, the Compton Gamma Ray Observatory and the Chandra X-ray Observatory, in exploring the cosmos across almost the entire electromagnetic spectrum. Later renamed the Spitzer Space Telescope, in honour of U.S. astronomer Lyman Spitzer, the 2,100 lb (950 kg) observatory has since carved its own niche in the annals of astrophysics and cosmology and continues to make astounding scientific discoveries.

As the only one of the four Great Observatories not launched by the Space Shuttle, it is more than a little ironic than SIRTF was originally conceived as a pallet-only Spacelab facility, with a 3.3 foot (1 metre) telescope and optical bench, operating from the payload bay of the reusable orbiter. In a 1979 report from the National Research Council of the National Academy of Sciences, it was described as "one of two major astrophysics facilities for Spacelab" and was deemed important for the development of long-duration, cryogenically-cooled space telescopes. The significance of SIRTF was that it would utilize a "dewar" of cryogenic helium to sufficiently cool its infrared detectors and thus meet the requirements to resolve its desired astronomical targets. Subsequent data from the 1983-launched Infrared Astronomy Satellite (IRAS) made the usefulness of SIRTF more obvious.

Anticipated for a first shuttle launch in 1990, and flying at one-yearly intervals thereafter, SIRTF encountered its first major hurdle when Challenger flew the Spacelab-2 payload of telescopes and astronomical detectors aboard Shuttle mission STS-51F in July-August 1985. Although this eight-day mission was an enormous scientific success, it demonstrated that the "dirty" environment of particulate contaminants around the Shuttle was poorly suited to the needs of high-energy astrophysics instruments. Contributing to the eventual demise of SIRTF as a Shuttle-borne payload was the Challenger disaster in January 1986, and after several phases of "re-scoping" and redesign it emerged as a spacecraft which would be lofted into orbit atop a Delta II booster.

The Spitzer Space Telescope was launched on a Delta II rocket on August 25, 2003 from Cape Canaveral, Florida.
*Photo: NASA/KSC*

As part of the redesign, SIRTF would be inserted into an "Earth-trailing" orbit, which is "heliocentric" (Sun-circling), rather than "geocentric" (Earth-circling), and involved the spacecraft drifting away from Earth's orbit at a rate of about 9.3 million miles (14.9 million km), or 0.1 Astronomical Units, per year. The reason was that Earth generates a large heat load and emplacement at this sufficiently distant point would enable SIRTF to utilise passive cooling technologies, including a large Sun-shield, to greatly reduce its operating temperature and the mass of cryogenic helium it needed to carry. Its telescope and cryogenic assembly were built by Ball Aerospace and its scientific instruments—the Infrared Array Camera

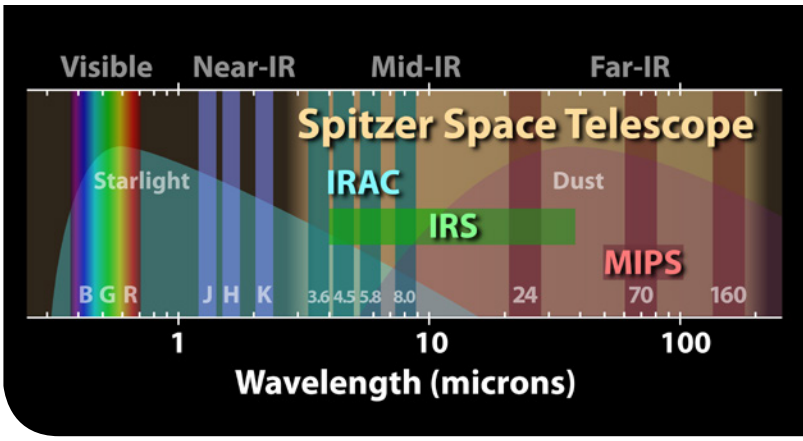
(IRAC), the Infrared Spectrograph (IRS), and the Multi-band Imaging Photometer for Spitzer (MIPS)—all featured significant involvement from academic and industry.

With a final price tag estimated at about $800 million, SIRTF rocketed into space from Space Launch Complex (SLC)-17B at Cape Canaveral Air Force Station, Fla., at 1:35 p.m. EDT on 25 August 2003. Original plans called for SIRTF to operate for at least 30 months, although it was hoped to run the observatory for as long as five years or until its liquid helium coolant was depleted. As circumstances transpired, this depletion did not occur until May 2009, after which it was determined that the two shortest-wavelength components of IRAC remained operable and a "Warm Mission" was authorised.

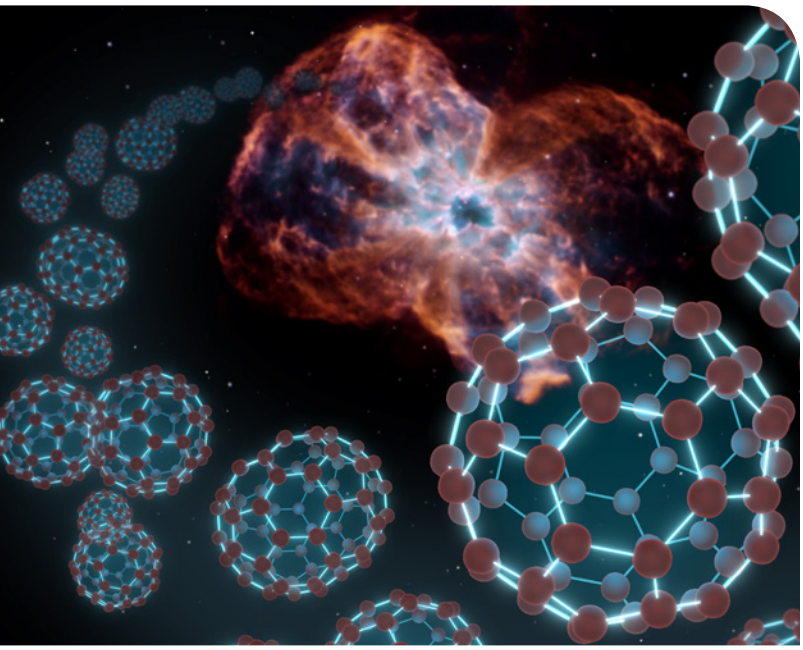
By this time, SIRTF had since been renamed in honour of the U.S. theoretical physicist and astronomer Lyman Spitzer (1914-1997), one of the earliest proponents for the idea of a space-based telescope. The formal announcement of the spacecraft's new name came in December 2003, when NASA lauded Spitzer's "vision and contribution to science" and noted that a NASA-sponsored contest had "received more than 7,000 essay entries from all over the world." The winning entry came from a resident of British Columbia.

Since then, the mechanical Spitzer has played an enormous role in opening our eyes and consciousness to the mysteries and wonders of the Universe around us. It has been used to examine comets and asteroids, count stars, scrutinise planets and galaxies and image football-shaped carbon spheres in space, known as 'buckyballs'. Particular focuses have included Comet Tempel 1—impacted by NASA's Deep Impact mission—and the surprising discovery in October 2009 of Saturn's largest ring. Now known as the "Phoebe ring", its existence had been predicted in the 1970s and it lies just interior of the orbit of the moon Phoebe. It was calculated to extend outward up to 300 Saturn radii and inward to the orbit of the moon Iapetus at 59 Saturn radii, making its thickness about 20 times that of the diameter of the giant planet itself.

Perhaps Spitzer's most astonishing finds came from beyond our Solar System. The telescope was the first to detect light coming from a planet outside the Sun's realm, which represented a feat not in the mission's original design. With Spitzer's ongoing studies of these exotic worlds, astronomers have been able to probe their composition, dynamics, and more, revolutionising the study of "exoplanet" atmospheres. Other discoveries and accomplishments of the mission include a complete census of forming stars in nearby clouds, a new and improved map of the Milky Way's spiral-arm structure,




This diagram illustrates where Spitzer's vision extends in the spectrum of light, shown as a horizontal band. Vertical bars indicate different regions of the electromatic spectrum. On the left is the visible spectrum, covering the extent of human vision. On the right are the wavelengths spanned by Spitzer's detectors.



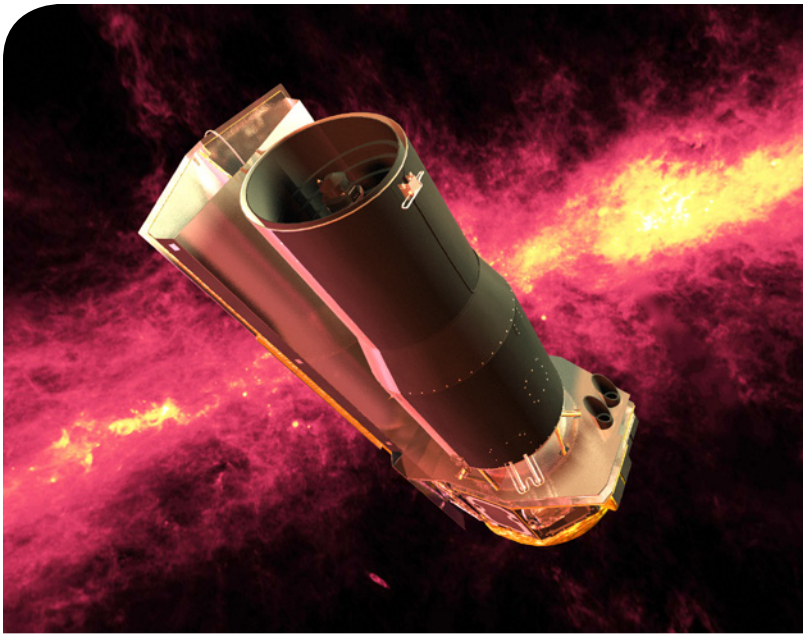
Spitzer has found buckyballs in space, as illustrated by this artist's conception showing the carbon balls coming out from the type of object where they were discovered – a dying star and the material it sheds, known as a planetary nebula.

*Image: NASA/JPL-Caltech/T. Pyle (SSC)*

and, with the Hubble Space Telescope, discovering that the most distant galaxies known are more massive and mature than expected.

Looking ahead, the observatory is expected to play an important part in the search for appropriate targets for President Barack Obama's goal of boots on an asteroid by the middle of the next decade. In October 2013, Spitzer was tasked to perform infrared observations of a small near-Earth asteroid, known as 2009 DB, to better determine its size and composition and assess its suitability for NASA's capture and redirect mission plan. "President Obama's goal of visiting an asteroid by 2025 combines NASA's diverse talents in a unified endeavour," said John Grunsfeld, NASA's associate administrator for science in Washington, D.C. "Using Spitzer to help us characterise asteroids and potential targets for an asteroid mission advances both science and exploration."

Only three Great Observatories currently remain in orbit and in operational service. The Hubble Space Telescope, launched aboard Shuttle mission STS-31 in April 1990, continues to return astonishing scientific results to this day and is expected to do so until at least 2014. The Compton Gamma Ray Observatory flew aboard Shuttle mission STS-37 in April 1991, but suffered a failure of one of its three gyroscopes in December 1999 and was intentionally de-orbited the following June. The Advanced X-ray Astrophysics Facility (AXAF)—later named "Chandra," in honour of the Indian astrophysicist Subramanyan Chandrasekhar—was launched into orbit in July 1999 aboard Shuttle mission STS-93. Like Hubble and Spitzer, it remains active to this day.



Spitzer seen against the infrared sky. The band of light is the glowing dust emission from the Milky Way galaxy seen at 100 microns (as seen by the IRAS/COBE missions). *Image: NASA/JPL-Caltech/R. Hurt (SSC)*

This glowing emerald nebula seen by Spitzer is reminiscent of the glowing ring wielded by the superhero Green Lantern. Astronomers believe rings like this are actually sculpted by the powerful light of giant "O" stars. Named RCW 120 by astronomers, this region of hot gas and glowing dust can be found in the constellation Scorpius.

*Image: NASA/JPL-Caltech/GLIMPSE-MIPSGAL Teams*

"I always knew Spitzer would work, but I had no idea that it would be as productive, exciting, and long-lived as it has been," said Spitzer project scientist Michael Werner of NASA's Jet Propulsion Laboratory in Pasadena, Calif., who helped conceive the mission. "The spectacular images that it continues to return, and its cutting-edge science, go far beyond anything we could have imagined when we started on this journey more than 30 years ago." Werner's comments were reinforced by Dave Gallagher, Spitzer's project manager at JPL from 1999-2004, who quoted the French novelist Marcel Proust: The real voyage of discovery consists not in seeking new landscapes, but in having new eyes.

# The images of Spitzer

*A decade in space. A lifetime of discoveries.*

**Helix Nebula:** Some say Spitzer's infrared view of the Helix nebula - a dying star and its scattered remains - resembles the eye a green monster.

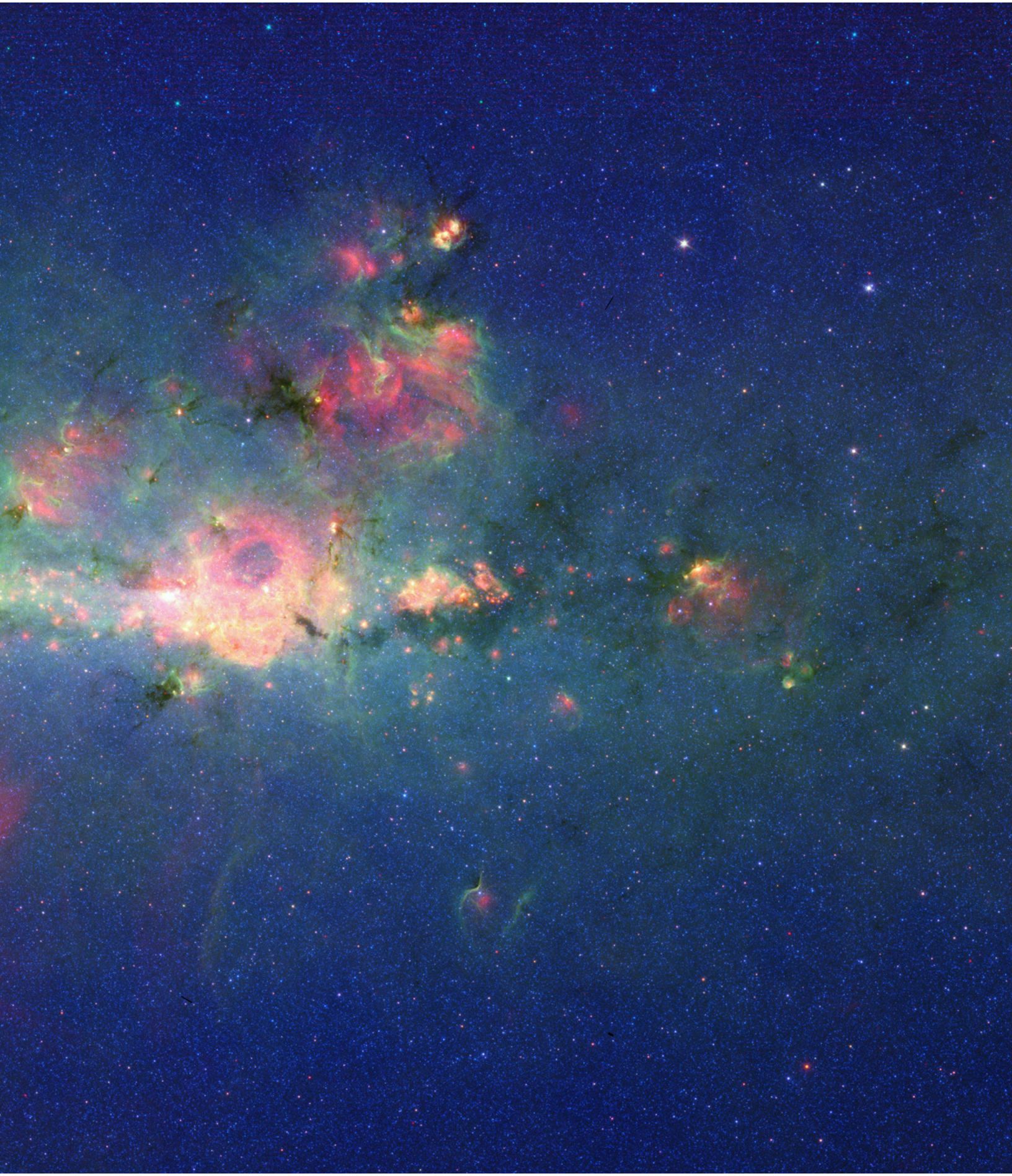
*Image: NASA/JPL-Caltech/Univ.of Ariz.*

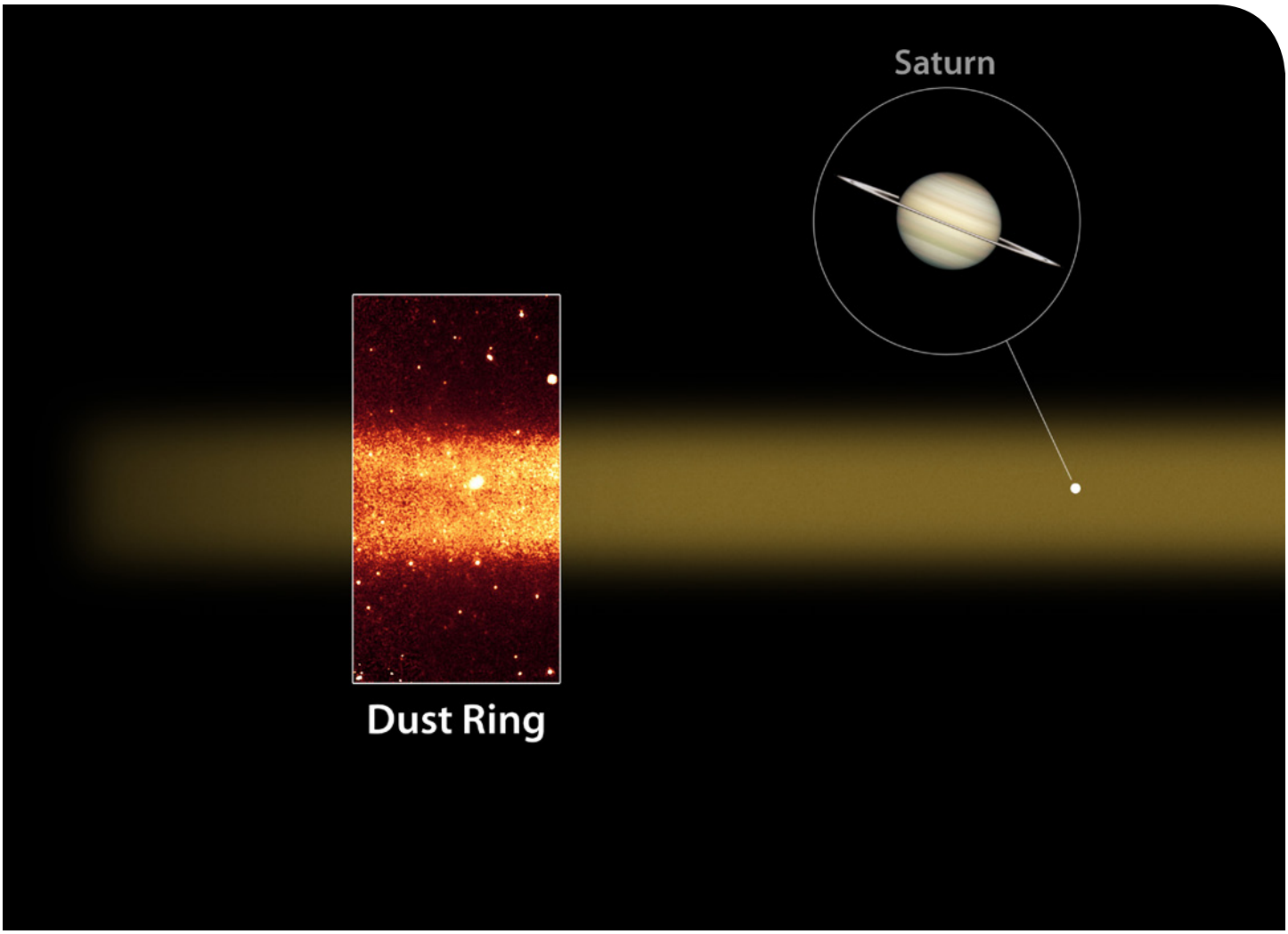
**Sword of Orion:**
This infrared image from Spitzer Space shows the Orion nebula, our closest massive star-making factory, 1,450 light-years from Earth.

*Image: NASA/JPL–Caltech/Univ. of Toledo*

**Stars Gather in 'Downtown' Milky Way:**
The region around the center of our Milky Way galaxy glows colorfully in this new version of an image taken by the Spitzer Space Telescope. The image is displayed (left picture) on a quarter-of-a-billion-pixel, high-definition 23-foot-wide (7-meter) LCD science visualization screen at NASA's Ames Research Center in Moffett Field, Calif.

*Images: NASA/Ames/JPL-Caltech*

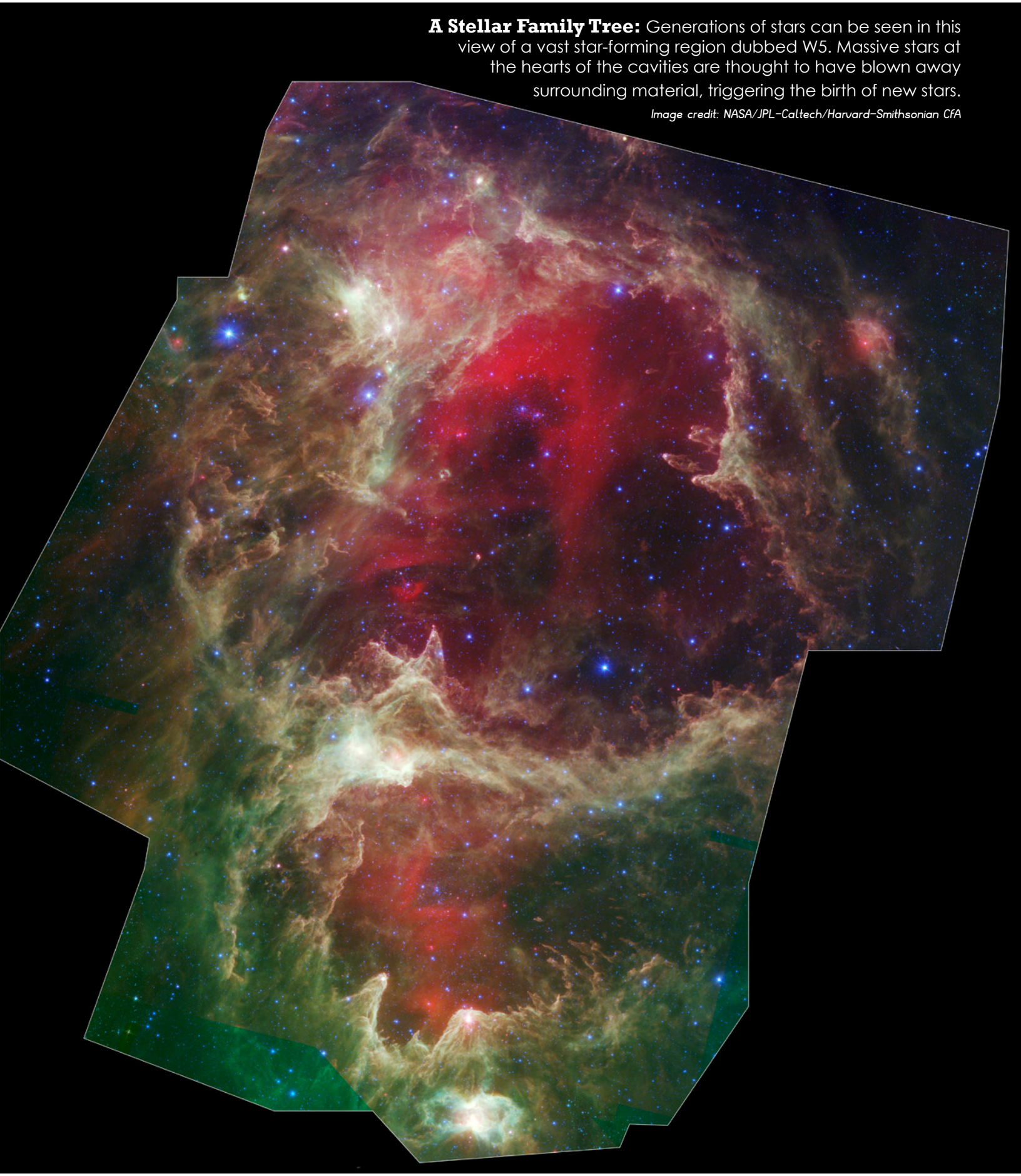





**Saturn's Largest Ring:** Spitzer surprised astronomers in 2009 when it discovered Saturn's largest ring, a slice of which is highlighted in this diagram. *Image: NASA/JPL-Caltech/Univ. of Virginia*

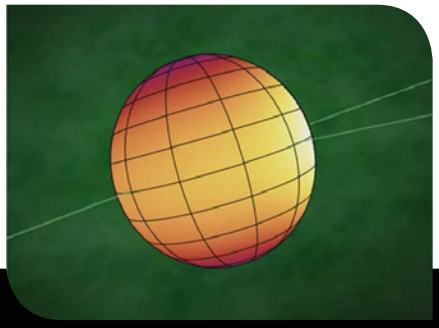
**Tortured Clouds of Eta Carinae:**
Massive stars can wreak havoc on their surroundings, as can be seen in this new view of the Carina nebula from the Spitzer Space Telescope.

*Image: NASA/JPL-Caltech*



**A Stellar Family Tree:** Generations of stars can be seen in this view of a vast star-forming region dubbed W5. Massive stars at the hearts of the cavities are thought to have blown away surrounding material, triggering the birth of new stars.

*Image credit: NASA/JPL-Caltech/Harvard-Smithsonian CfA*

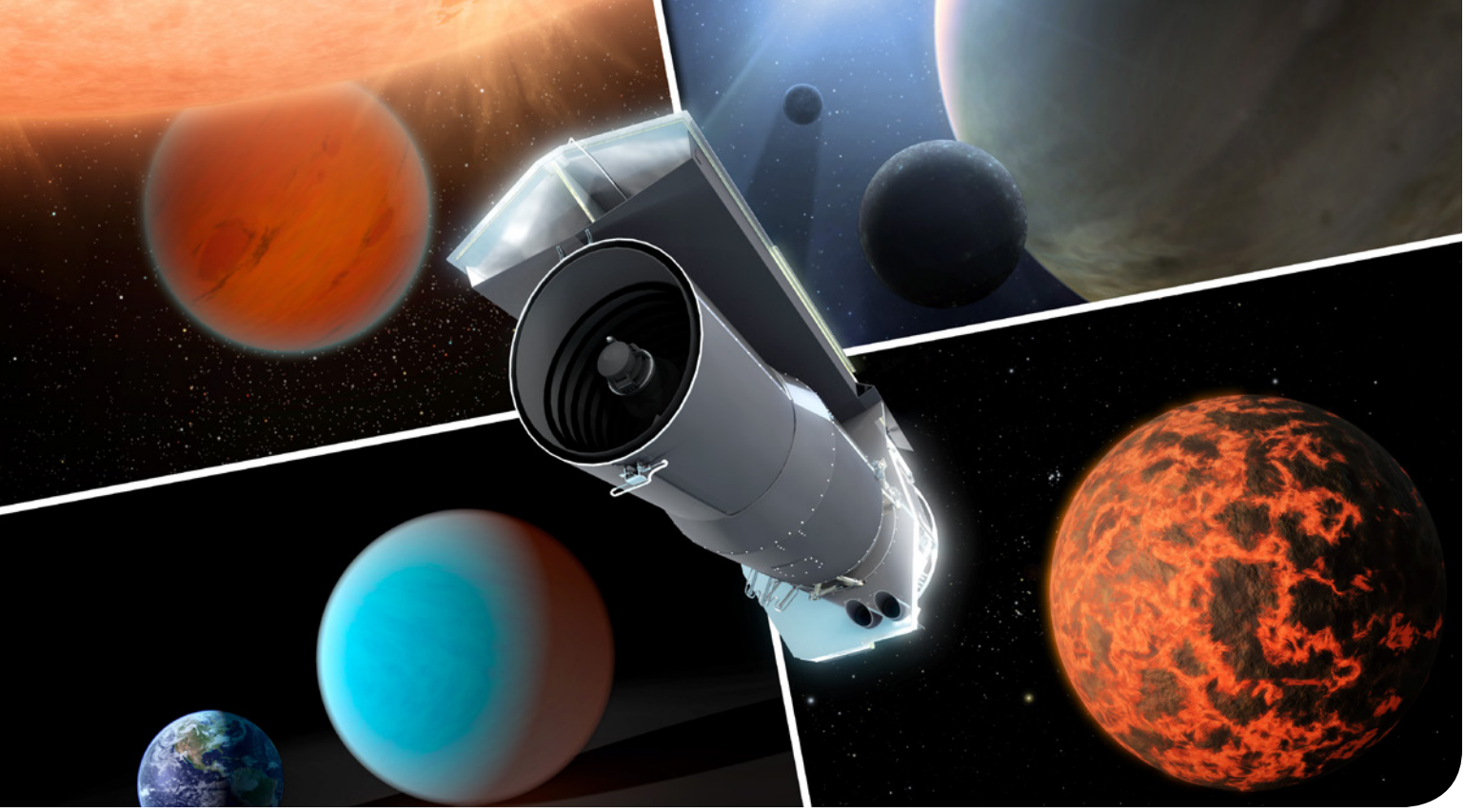


**Alien Globe:** This image shows the first-ever map of the surface of an exoplanet, or a planet beyond our solar system. The map, which shows temperature variations across the cloudy tops of a gas giant called HD 189733b, is made up of infrared data taken the Spitzer. Hotter temperatures are represented in brighter colors.

*Image: NASA/JPL-Caltech/Harvard-Smithsonian CfA*

**Young Stars Cradled in Dust:**
Newborn stars peek out from beneath their natal blanket of dust in this dynamic image of the Rho Ophiuchi dark cloud from Spitzer.

*Image: NASA/JPL-Caltech/Harvard-Smithsonian CfA*



This artist's concept shows Spitzer surrounded by examples of exoplanets the telescope has examined. *Image: NASA/JPL-Caltech*

# How engineers revamped Spitzer to probe exoplanets

Passing its 10th anniversary, NASA's Spitzer Space Telescope has evolved into a premier observatory for an endeavor not envisioned in its original design: the study of worlds around other stars, called exoplanets.

While the engineers and scientists who built Spitzer did not have this goal in mind, their visionary work made this unexpected capability possible. Thanks to the extraordinary stability of its design and a series of subsequent engineering reworks, the space telescope now has observational powers far beyond its original limits and expectations.

"When Spitzer launched back in 2003, the idea that we would use it to study exoplanets was so crazy that no one considered it," said Sean Carey of NASA's Spitzer Science Center at the California Institute of Technology in Pasadena. "But now the exoplanet science work has become a cornerstone of what we do with the telescope."

Spitzer views the universe in the infrared light that is a bit less energetic than the light our eyes can see. Infrared light can easily pass through stray cosmic gas and dust, allowing researchers to peer into dusty stellar nurseries, the centers of galaxies, and newly forming planetary systems.

This infrared vision of Spitzer's also translates into exoplanet snooping. When an exoplanet crosses or "transits" in front of its star, it blocks out a tiny fraction of the starlight. These mini-eclipses as glimpsed by Spitzer reveal the size of an alien world.

Exoplanets emit infrared light as well, which Spitzer can capture to learn about their atmospheric compositions. As an exoplanet orbits its sun, showing different regions of its surface to Spitzer's cameras, changes in overall infrared brightness can speak to the planet's climate. A decrease in brightness as the exoplanet then goes behind its star can also provide a measurement of the world's temperature.

While the study of the formation of stars and the dusty environments from

which planets form had always been a cornerstone of Spitzer's science program, its exoplanet work only became possible by reaching an unprecedented level of sensitivity, beyond its original design specifications.

Researchers had actually finalized the telescope's design in 1996 before any transiting exoplanets had even been discovered. The high degree of precision in measuring brightness changes needed for observing transiting exoplanets was not considered feasible in infrared because no previous infrared instrument had offered anything close to what was needed.

Nevertheless, Spitzer was built to have excellent control over unwanted temperature variations and a better star-targeting pointing system than thought necessary to perform its duties. Both of these foresighted design elements have since paid dividends in obtaining the extreme precision required for studying transiting exoplanets.

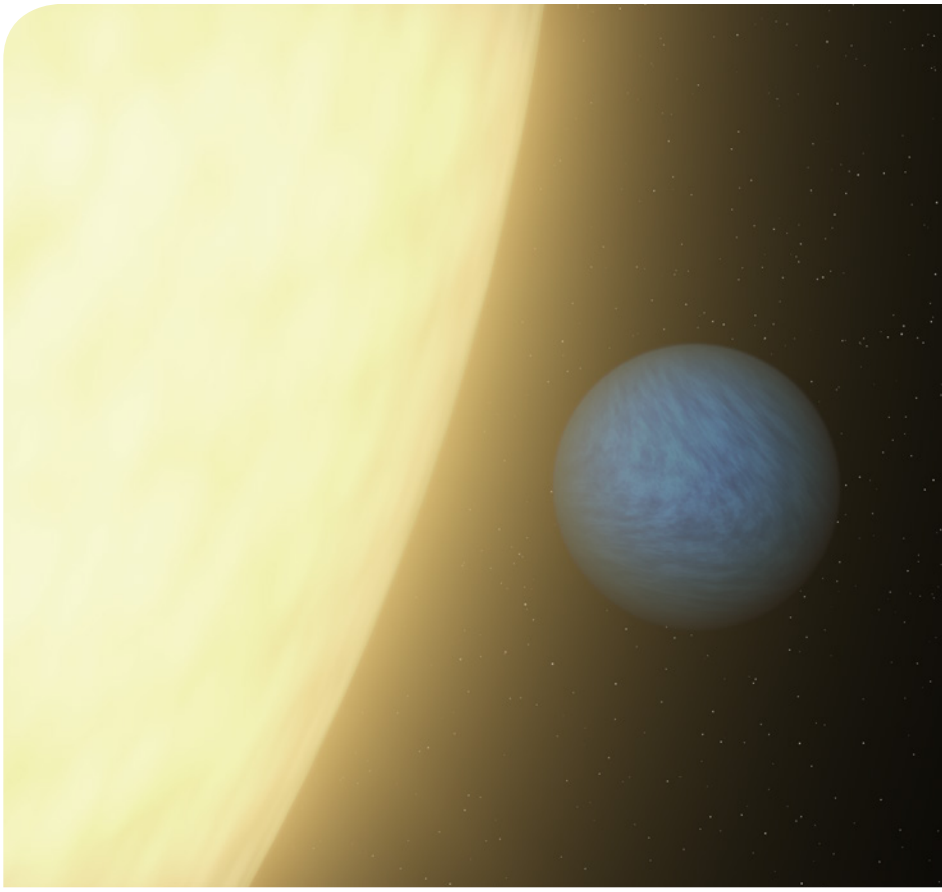
The fact that Spitzer can still do any science work at all still can be credited to some early-in-the-game, innovative thinking. Spitzer was initially loaded with enough coolant to keep its three temperature-sensitive science instruments running for at least two-and-a-half years. This "cryo" mission ended up lasting more than five-and-a-half-years before exhausting the coolant.

But Spitzer's engineers had a built-in backup plan. A passive cooling system has kept one set of infrared cameras humming along at a super-low operational temperature of minus 407 degrees Fahrenheit (minus 244 Celsius, or 29 degrees above absolute zero). The infrared cameras have continued operating at full sensitivity, letting Spitzer persevere in a "warm" extended mission, so to speak, though still extremely cold by Earthly standards.

To stay so cool, Spitzer is painted black on the side that faces away from the sun, which enables the telescope to radiate away a maximum amount of heat. On the sun-facing side, Spitzer has a shiny coating that reflects as much of the heat from the sun and solar panels as possible. It is the first infrared telescope to use this innovative design and has set the standard for subsequent missions.

Fully transitioning Spitzer into an exoplanet spy required some clever modifications in-flight as well, long after it flew beyond the reach of human hands into an Earth-trailing orbit. Despite the telescope's excellent stability, a small "wobbling" remained as it pointed at target stars. The cameras also exhibited small brightness fluctuations when a star moved slightly across an individual pixel of the camera. The wobble, coupled with the small variation in the cameras, produced a periodic brightening and dimming of light from a star, making the delicate task of measuring exoplanet transits that much more difficult.

To tackle these issues, engineers first began looking into a source for the wobble. They noticed that the telescope's trembling followed an hourly cycle. This



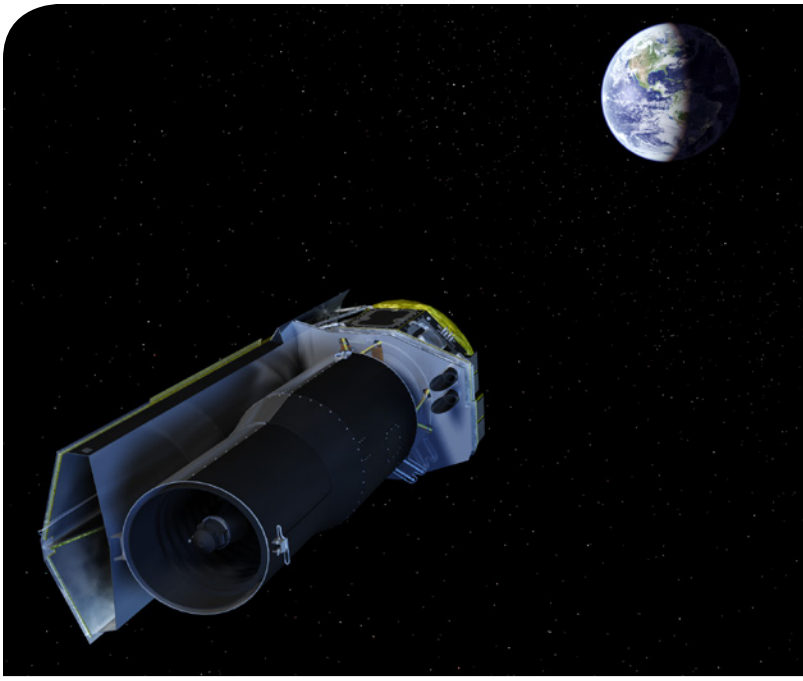
Spitzer was able to detect a super Earth's direct light for the first time using its sensitive heat-seeking infrared vision. Seen here in this artist's concept, the planet is called 55 Cancri e. Data revealed that it is very dark and that its sun-facing side is blistering hot at 3,140 degrees Fahrenheit. *Image: NASA/JPL-Caltech*

cycle, it turned out, coincided with that of a heater, which kicks on periodically to keep a battery aboard Spitzer at a certain temperature. The heater caused a strut between the star trackers and telescope to flex a bit, making the position of the telescope wobble compared to the stars being tracked.

Ultimately, in October 2010, the engineers figured out that the heater did not need to be cycled through its full hour and temperature range – 30 minutes and about 50 percent of the heat would do. This tweak served to cut the telescope's wobble in half.

Spitzer's engineers and scientists were still not satisfied, however. In September 2011, they succeeded in repurposing Spitzer's Pointing Control Reference Sensor "Peak-Up" camera. This camera was used during the original cryo mission to put gathered infrared light precisely into a spectrometer and to perform routine calibrations of the telescope's star-trackers, which help point the observatory.

The telescope naturally wobbles back and forth a bit as it stares at a particular target star or object. Given this unavoidable jitter, being able to control where light goes within the infrared camera is critical for obtaining precise measurements. The engineers applied the Peak-Up to the infrared camera observations, thus allowing astronomers to place stars precisely on the center of a camera pixel.



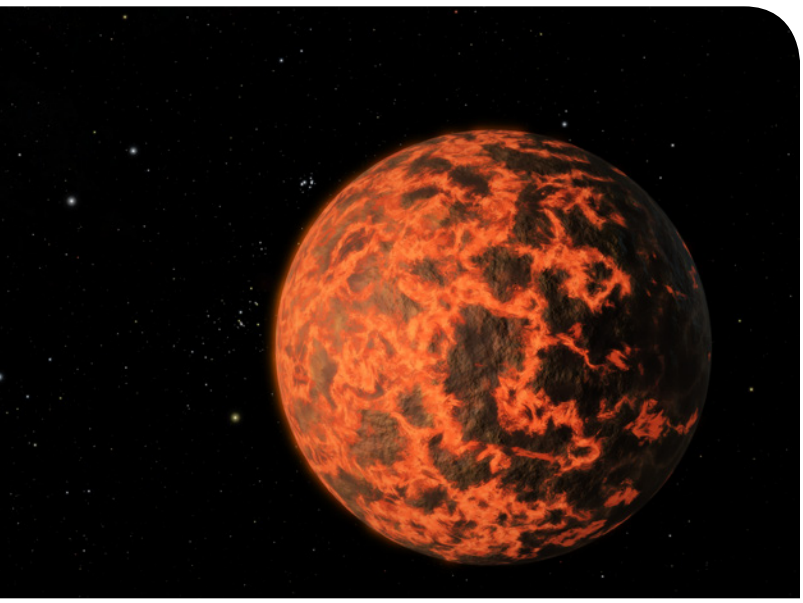
The Spitzer Space Telescope points its high-gain antenna towards the Earth for downlinking recent observations and uplinking new observing instructions. *Image: NASA/JPL-Caltech/R. Hurt (SSC)*

Since repurposing the Peak-Up Camera, astronomers have taken this process even further, by carefully "mapping" the quirks of a single pixel within the camera. They have essentially found a "sweet spot" that returns the most stable observations. About 90 percent of Spitzer's exoplanet observations are finely targeted to a sub-pixel level, down to a quarter of a pixel.

"We can use the Peak-Up camera to position ourselves very precisely on the camera and put light right on the best part of a pixel," said Carey. "So you put the light on the sweet spot and just let Spitzer stare."

These three accomplishments – the modified heater cycling, repurposed Peak-Up camera and the in-depth characterization of individual pixels in the camera – have more than doubled Spitzer's stability and targeting, giving the telescope exquisite sensitivity when it comes to taking exoplanet measurements.

"Because of these engineering modifications, Spitzer has been transformed into an exoplanet-studying telescope," said Carey. "We expect plenty of great exoplanetary science to come from Spitzer in the future."



Astronomers using the Spitzer Space Telescope have detected an alien world just two-thirds the size of Earth. The exoplanet candidate, known as UCF-1.01, orbits a star called GJ 436, which is located 33 light-years away. *Image: NASA/JPL-Caltech/R. Hurt (SSC)*

## NASA and JAXA launch new satellite to measure global rain and snow

The Global Precipitation Measurement (GPM) Core Observatory, a joint Earth-observing mission between NASA and the Japan Aerospace Exploration Agency (JAXA), thundered into space Feb. 27 from Japan.

The four-ton spacecraft launched aboard a Japanese H-IIA rocket from Tanegashima Space Center on Tanegashima Island in southern Japan. The GPM spacecraft separated from the rocket 16 minutes after launch, at an altitude of 247 miles (398 kilometers).

*Photos: NASA/Bill Ingalls*

Photo: Chris Haber

## Delta IV takes military GPS satellite into orbit

A United Launch Alliance (ULA) Delta IV rocket successfully launched the Global Positioning System (GPS) IIF-5 satellite for the U.S. Air Force on Feb. 20 at 8:59 p.m. EST from Space Launch Complex-37. The rocket was delayed until the last minute of the launch window due to solar activity.

GPS IIF-5 is the fifth in a series of 24 next-generation GPS satellites. The GPS IIF series provides improved accuracy and enhanced performance for GPS users.

Photo: Julian Leek/JNN