



Epic goals of humankind: from our own backyard to beyond our own galaxy

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## TTSIQ Sponsor Organizations



### About The National Space Society – <http://www.nss.org/>

The National Space Society was formed in March, 1987 by the merger of the L5 Society and National Space institute. NSS has an extensive chapter network in the United States and a number of international chapters in Europe, Asia, and Australia. NSS hosts the International Space Development Conference in May each year at varying locations. NSS publishes **Ad Astra** magazine quarterly. NSS actively tries to influence US Space Policy.

### About The Moon Society – <http://www.moonsociety.org>

The Moon Society was formed in 2000 and seeks to inspire and involve people everywhere in exploration of the Moon with the establishment of civilian settlements, using local resources through private enterprise both to support themselves and to help alleviate Earth's stubborn energy and environmental problems. The Society has a network of chapters in the US and has been an affiliate of NSS since 2005.

### About Space Renaissance Initiative – <http://www.spacerenaissance.org/>

SRI's focus is on use of space resources to address the challenges of runaway population growth and increasing use of Earth resources at a non-sustainable pace. "The settlement of space would benefit all of humanity by opening a new frontier, energizing society, providing room and resources for the growth of the human race without despoiling Earth, creating a lifeboat for humanity that could survive even a planet-wide catastrophe."

### About The Mars Foundation – <http://marsfoundation.org/> – <http://marshome.org/>

The Foundation seeks to involved interested persons in the design of Mars outposts and settlements, maximizing use of building materials that can be produced on Mars, to illustrate the near-term feasibility of establishing a permanent human presence on Mars.

### About Open Luna Foundation – <http://openluna.org/missions>

The OpenLuna Foundation aims to return to the moon through private enterprise. A stepped program of robotic missions, then a short series of manned missions to construct a small, approximately 8 person outpost .

### About SEDS: Students for the Exploration and Development of Space – <http://www.seds.org/>

SEDS is an independent, student-based organization promoting the exploration and development of space by educating people about the benefits of space, via a network of interested students, providing an opportunity

### About Moon Miners' Manifesto – <http://www.MMM-MoonMinersManifesto.com>

MMM, has been published 10 times a year since issue #1 December 1986 by the Milwaukee Lunar Reclamation Society chapter of the **National Space Society**. It has also served **the Moon Society** and its predecessor, Artemis Society International, since October 1995.

Most issues deal with the **opening of the Lunar frontier**, suggesting how pioneers can make best use of **local resources** and learn to **make themselves at home**. This will involve psychological, social, and physiological adjustment. Much of what will hold for the **Moon**, will also hold true for **Mars** and for space in general. There is one Mars theme issue each year, and occasionally **other space destinations** are discussed: the asteroids, Europa (Jupiter), Titan (Saturn), even the cloud tops of Venus, and interstellar destinations beyond.



- Most of the “editor’s summaries” of news articles will be in the form of bullet points of the contents. We welcome your comments – Peter Kokh, Editor, [kokhmmm@aol.com](mailto:kokhmmm@aol.com)



NATIONAL & INTERNATIONAL SPACE AGENCIES

SPACEPORT NEWS

ANALOG FACILITY TRAINING

### NASA Prepares for Future Space Exploration with International Undersea Crew

[www.nasa.gov/press-release/nasa-prepares-for-future-space-exploration-with-international-undersea-crew](http://www.nasa.gov/press-release/nasa-prepares-for-future-space-exploration-with-international-undersea-crew)

26 June, 2015 – NASA will send an international crew to the bottom of the Atlantic Ocean this summer to prepare for future deep space missions during the 14-day **NASA Extreme Environment Mission Operations (NEEMO) 20** expedition slated to begin July 20.



NEEMO 16 aquanauts Kimiya Yui and Tim Peake pose with their support diver and astronaut Mike Gernhardt in the DeepWorker single-person submarine.

- NEEMO 20 will focus on evaluating tools and techniques being tested for future spacewalks on a variety of surfaces and gravity levels ranging from asteroids to the moons of Mars and Mars’ surface.
- There have been 20 missions at Aquarius in the past 15 years: Living and working in the highly operational, isolated and extreme environment of the sea floor has provided significant science and engineering for the benefit of human spaceflight.
- It has also clearly proven to be as close to spaceflight as is possible here on Earth.
- The mission will test time delays in communications due to the distance of likely mission destinations.



- The crew will assess hardware from the European Space Agency that allows crew members to read the next step in a procedure without taking hands or eyes away from the task using a tablet, a smartphone and a head-mounted interface.
- The NEEMO crew and two professional habitat technicians will live 19 m (62 ft) below the surface of the Atlantic Ocean in Florida International University's Aquarius Reef Base undersea research habitat 6.2 mi (5.4 nautical mil) off the coast of Key Largo, Florida.
- For more information about NEEMO, the crews, etc., visit: <http://www.nasa.gov/neemo>

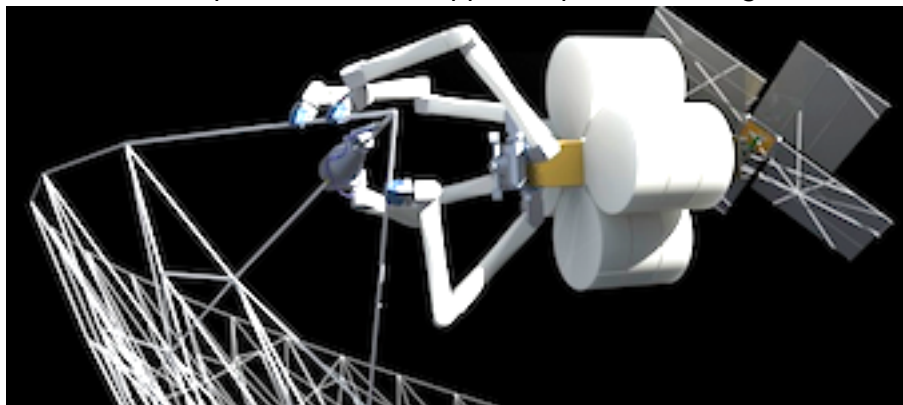
## BUILDING IN SPACE

### Spiderlike Robots Could Build Giant Space Structures

7 April, 2015 – [www.space.com/28846-spiderfab-space-structures-incredible-technology.html](http://www.space.com/28846-spiderfab-space-structures-incredible-technology.html)

Humanity could soon be building huge structures in space one piece at a time, the way spiders spin their webs here on Earth.

- **Tethers Unlimited** is developing an **in-space manufacturing system** called "**SpiderFab**," using spider-like robots to put together large objects in orbit or beyond.
- SpiderFab could help build big radio antennas, space booms, and solar arrays in the next decade.
- But the company has an even grander vision for the technology and associated projects.
- Its really long-term objective for all of this work is to eventually enable the use of in-situ resources to construct the infrastructure in space needed to support expansion throughout the the solar system.



Tethers Unlimited envisions using spider-like robots (seen here in an artist's concept) to assemble huge structures in space.

#### Bringing costs down

- The current model of spacecraft manufacturing — in which everything is built and assembled on the ground, and is then launched in one piece is a very expensive and time-consuming process.
- And the size of systems is somewhat limited by the size of the deployables that are possible to fold up and fit within a launch shroud
- SpiderFab is an effort to decrease costs and increase efficiencies by launching raw materials, such as carbon fiber, to orbit. There, robots would transform these materials into truss substructures, and then assemble and integrate these pieces into larger systems.

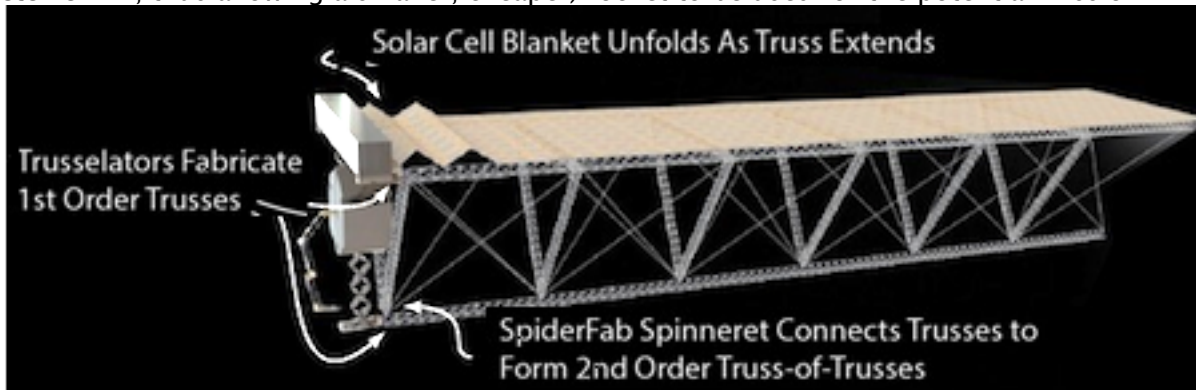
#### The potential benefits of such an approach are substantial.

- We can deploy apertures and baselines much larger than we can currently fit into launch shrouds,
- The payoff will be higher power, higher resolution, higher sensitivity and higher bandwidth for a wide range of NASA, DoD [Department of Defense] and commercial space missions.
- Objects built in space can be sleeker and simpler than ones launched from the ground, since they don't need to survive the rigors of launch.
- That should lead to reductions in design complexity and system mass at significant cost savings,.

#### Case studies



- SpiderFab has received two rounds of funding from the NASA Innovative Advanced Concepts (NIAC) program, to encourage the development of potentially game-changing space technologies.
- Case-study analyses under the Phase 1 NIAC award indicated that SpiderFab could achieve order-of-magnitude performance improvements in "bigger is better" systems: solar arrays and telescope parts.
- An example is the proposed New Worlds Observer (NWO) space telescope which would use a huge "starshade" to block out most of the light of a star, allowing exoplanets to be imaged directly.
- The largest conventionally built **starshade** would be about 62 m (203 ft) wide. Employing on-orbit manufacturing with the same amount of mass would increase that diameter to 124 m (406 ft), allowing NWO to peer twice as close to target stars — and thus observe more planets.
- **Launching the starshade in raw-material form, instead of in finished form, reduces its volume by a factor of 30**, thus allowing a smaller, cheaper) rocket to be used for the potential mission.



Tethers Unlimited has already built a machine that makes supporting truss structures here on Earth using a process akin to 3D printing. Here's an artist's concept of the "trusselator" technology at work in space.

#### How it will work

- At the heart of the SpiderFab concept is a "multiarmed robot" that would fabricate structural elements with one "spinneret" and use another one to join pieces together as it crawls about the growing "web."
- Tethers Unlimited, based in Bothell, Washington, is developing the various technologies required.
- Funded by NASA's Small Business Innovation Research (SBIR) program, a machine to create lightweight structural trusses from raw carbon-fiber spools, a process akin to 3D printing, has already been built.
- This "trusselator," about the size of a microwave oven, can churn out truss — the type of stuff that could be put together to form a spacecraft boom and other systems — at the rate 5 cm (2 in) /minute.
- The team is now working on a 2nd-generation trusselator, with a prototype ready by early summer. And wants to launch a small "MakerSat" in a couple of years to demonstrate the process on orbit.
- This spacecraft may end up being a CubeSat deployed from the International Space Station.
- The company bought a commercial Baxter robot to learn how to assemble trusses robotically.
- The company will continue to develop and refine this process on the ground, and then aim to launch a "MakerSat 2" to prove it out in space — perhaps by building the truss structure for a big starshade.
- If funding flowed and the contracting process doesn't drag on forever — they could be able to build very large support structures for antennas and solar arrays, etc., in the early 2020s. ##

## CUBESAT NEWS

### Indian firm to build indigenous "small satellites"

[www.dhruvaspace.com](http://www.dhruvaspace.com) – [www.facebook.com/DhruvaSpace](https://www.facebook.com/DhruvaSpace)



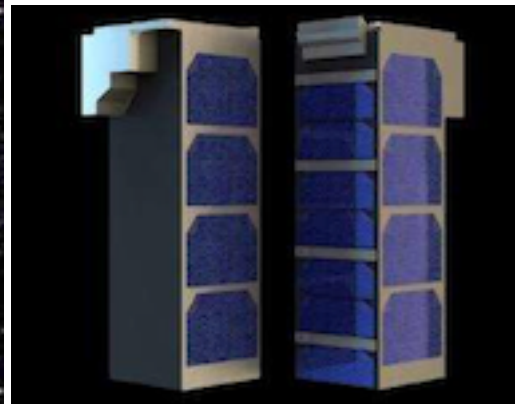
(Editor: from the few photos available, these "small satellites" resemble cubesats.)

#### Earlier Story:

<http://economictimes.indiatimes.com/news/science/inspired-from-isros-mars-mission-dhruva-space-gears-up-for-commercial-launch-within-two-years/>

## CubeSats offered deep-space ride on ESA asteroid probe

26 February 2015 – [www.phys.org/news/2015-02-cubesats-deep-space-esa-asteroid-probe.html](http://www.phys.org/news/2015-02-cubesats-deep-space-esa-asteroid-probe.html)



**L:** Launching October 2020, ESA's Asteroid Impact Mission spacecraft will be our first mission to a binary system – the paired Didymos asteroids – a comparatively close 11 million km to Earth in 2022. The 800 m-diameter main body is orbited by a 170 m Moon. AIM will perform high resolution visual, thermal and radar mapping of the moon. It will also put down a lander

**R:** A pair of triple-unit CubeSats. ESA's 2020 Asteroid Impact Mission spacecraft will have room to carry six CubeSat units – potentially single-unit miniature spacecraft but more probably a pair of larger CubeSats as seen here.

- ESA will give CubeSats a ride to a pair of asteroids: the ultimate hitchhiking opportunity: .
- CubeSats are among the smallest types of satellites: formed in standard cubic units of 10 cm per side, they provide affordable access to space for small companies, research institutes and universities. One-, two- or three- or more unit CubeSats are already being flown.
- Teams of researchers and companies from any ESA Member State are free to compete.
- When the Asteroid Impact Mission (AIM) is launched in October 2020, the selected CubeSats will become Europe's first to travel beyond Earth orbit.
- AIM has room for a total of six CubeSat units – that might mean six different one-unit CubeSats could fly, or it might turn out that two three-unit CubeSats will be needed for good scientific return.
- "Wanted: innovative ideas for CubeSat-hosted sensors to boost and complement scientific return."
- The plan is to use these CubeSats, together with AIM itself and its asteroid lander, **to test out inter-satellite communications networking.**
- ESA's SysNova initiative will survey a comparatively large number of alternative solutions.

- This competition framework gives industry and universities the opportunity to work together on developing their scientific investigations in a field that is the technological cutting edge. ##

## Tiny Cubesats Set to Explore Deep Space

11 May, 2015 – [www.space.com/29306-cubesats-deep-space-exploration.html](http://www.space.com/29306-cubesats-deep-space-exploration.html)  
[www.space.com/29320-cubesats-spacecraft-tech-explained-infographic.html](http://www.space.com/29320-cubesats-spacecraft-tech-explained-infographic.html)

Tiny space probes are set to make a giant leap away from Earth's neighborhood, helping researchers study and explore the Moon, asteroids and other distant bodies.

- Cubesats will enable some new kinds of measurements and whole new missions to be done.

### Small, cheap and efficient

- The basic building block of cubesats is a cube measuring 10 cm (4") on each side. Satellites that consist of just a single such block are known as 1U (short for "one unit") cubesats; those that combine two or three of them are 2U and 3U, respectively. A 3U cubesat is about the size of a loaf of bread.
- Due to the electronics advances that are propelling the computer and cellphone industries, cubesats can be quite capable machines, with an extremely low price tag compared to traditional spacecraft.

### PhoneSat: Cubesat meet Cellphone: functional spacecraft based on consumer-grade electronics

- NASA's Ames Research Center leads a project called "PhoneSat" that uses off-the-shelf smartphones as the control systems for 1U cubesats.
- The first three PhoneSats — named Alexander, Graham and Bell after the telephone pioneer — launched to low-Earth orbit in April 2013.
- Each satellite cost about \$3,500 to build.

### Studying Earth

- A number of cubesats are already studying Earth and beaming down data for commercial use.
- The "Doves" 3U cubesats capture imagery with a resolution of 3–5 m (10–16.5 ft) from Earth orbit.
- The first two Doves flew in April 2013 and since then 71 more
- The aim is to make information about our planet much more accessible to a variety of customers.

### Exploring deep space

- Researchers are also working to send the tiny spacecraft much farther afield in the near future.
- The **Interplanetary NanoSpacecraft Pathfinder In Relevant Environment (INSPIRE)** will launch two identical 3U cubesats on an Earth-escape trajectory to about 1.5 million km (930,000 mi) from Earth.
- The INSPIRE cubesats carry a magnetometer and imager to study the fine structure of the solar wind.
- Both INSPIRE spacecraft have been built and are currently sitting in storage, awaiting assignment to a rocket as secondary payloads.
- The mission costs a total of \$5.5 million— extremely cheap compared to traditional deep-space efforts but more than typical university-led projects that design cubesats for use in Earth orbit.

### Asteroids, Mars and the moon

- Two 6U cubesats may launch with NASA's Mars InSight lander mission in March 2016 to help relay communications back to Earth during the probe's entry, descent and landing phase that September.
- At least three 6U cubesats are scheduled to launch on the first flight of NASA's Space Launch System (SLS) megarocket, which will send an Orion capsule on an unmanned trip around the Moon in 2018. **Lunar Flashlight, Near-Earth Asteroid (NEA) Scout** and **BioSentinel** — will all explore deep space.
- BioSentinel will circle the Sun and measure the effects of radiation on the DNA of onboard yeast cells.
- NEA Scout will use an 80 sq m (860-sq-ft) [solar sail](#) to cruise out to and study a near-Earth asteroid.
- **Lunar Flashlight** will use an identical solar sail to enter lunar orbit to look for ice on the Moon.
- Solar sailing is a promising way for cubesats, with little room for propellants, to travel long distances.

### What can interplanetary cubesats do?

- Cubesats could be carried to faraway places by large parent spacecraft, then deployed to conduct a variety of risky mini-missions — plummeting into a planet or moon on purpose as an impactor, or flying through the geysers of water ice that erupt from the south pole of the [Saturn moon Enceladus](#).
- Inexpensive cubesats may do some dangerous risky work in far-off places.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



- A fleet of cubesats could also take measurements simultaneously at multiple locations.
- That allows us to sort out time from spatial variability in magnetic fields, plasma and all the different measurements that go along with that, which is simply impossible to do from a single platform,.
- We are sure to find more “niches” for cubesats to contribute ##

## Tiny 'Cubesats' Gaining Bigger Role in Space

22 May, 2015 – [www.space.com/29464-cubesats-space-science-missions.html](http://www.space.com/29464-cubesats-space-science-missions.html)

[www.space.com/29320-cubesats-spacecraft-tech-explained-infographic.html](http://www.space.com/29320-cubesats-spacecraft-tech-explained-infographic.html)

When Jordi Puig-Suari and Bob Twiggs began working on the first cubesat in 1999, their goal was a rather basic one — **to develop a compact satellite that university students could build and use to conduct scientific experiments and test out new technologies.**

- Sixteen years later, cubesats have become major tools for governments conducting a variety of missions and for companies earning revenues from space.
- Cubesats have begun to outgrow their original 4x4x4-inch (10x10x10 centimeters) "1U" size.
- A 3-day workshop was attended by academic researchers, commercial vendors, government officials.
- The width and breadth of the missions discussed and the technologies involved has grown.
- Ambitious missions that would have been unthinkable a decade earlier.
- JPL will send two cubesats into deep space to provide real-time coverage of the entry, descent and landing of the space agency's Mars Insight lander.
- The Planetary Society's Lightsail craft packs a 32 sq m (344-sq-ft) solar sail inside a 3U cubesat, to test out technologies ahead of a more involved orbital sailing trial next year.
- NASA's BioSentinel mission, to launch in 2018, is designed to determine how much damage radiation does to DNA beyond low-Earth orbit. — as will follow 6U cubesats [Lunar Flashlight](#) and Near-Earth Asteroid Scout, which will hunt for water ice on the Moon and study a space rock, respectively.
- NanoSwarm, is focused on the study of particles and magnetic fields of airless planetary bodies.
- While most cubesats have ridden to space as secondary payloads aboard large rockets, new companies are beginning to develop small-satellite launch vehicles.

**See report on first cubesats to Mars in the Mars News Section Below**

## Bill Nye Launches Kickstarter to Push Solar Sailing Cubesat to Space

13 May, 2015 – [www.space.com/29402-bill-nye-lightsail-spacecraft-kickstarter.html](http://www.space.com/29402-bill-nye-lightsail-spacecraft-kickstarter.html)



Fully-deployed, The Planetary Society's LightSail will span 32 sq. m. (44 sq. ft)

- Bill Nye ("The Science Guy") wants you to be a part of a "revolutionary solar sailing spacecraft" mission.
- As Planetary Society leader, Nye has launched a **crowdfunding “campaign for the “lightsail”** a "citizen-funded flight by light" to realize a space travel concept pushed by Carl Sagan 40 years ago.

**A tiny CubeSat, no bigger than a breadbox, propelled by beams of light**

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- Through this proof-of-concept mission, ae CubeSats will open new paths beyond Earth and one day potentially to other planets with an inexpensive, inexhaustible means of propulsion, sunlight.
- To raise the \$200,000 plus needed for the mission, Nye and The Planetary Society are giving away square centimeter samples of the solar sail itself – and other perks in return for pledges.

### Gaining momentum

- Light is made of photons and photons have no mass – bt they have momentum.
- When sunlight shines on something, it is actually giving it a tiny, tiny push.
- Spacecraft can capture this momentum by using a large, lightweight mirrored surface.

### Mylar sails one fourth as thick as an average trash bag

- As light reflects off the Mylar, most of its momentum is transferred, pushing on the sail. The resulting acceleration is small, but it is continuous, such that the spacecraft can reach higher speeds over time.

### A May 20 test flight on an Atlas V rocket from Cape Canaveral, Florida

- The test will take the prototype to low-Earth orbit for about 30 days,
- The prototype will not soar high enough above the Earth's atmosphere to demonstrate solar sailing. About one week after sail deployment, the LightSail's orbit will decay and it will burn-up on re-entry.
- The primary LightSail mission, slated for launch in fall 2016, will get to orbit on a SpaceX Falcon Heavy rocket, "if" the Planetary Society can raise the remaining \$1.2 million that the full \$5.45 million the mission will cost.

### The campaign reached its "ambitious" goal of \$200,000 on just its second day

- "We don't expect to get [the remaining funds all from one source at one time, but you can put us on the trajectory to launching in 2016,"
- Nye said. "We're setting an ambitious Kickstarter goal of \$200,000, with stretch goals that take us all the way up to the \$1 million mark."
- Most of that support has come in the form of **\$35 pledges**, which is rewarded with a mission emblem decal and pin or patch, a Planetary Society membership, and a "centimeter of sail."
- \$35 Backers will own one square centimeter of LightSail, and a certificate of ownership to go with it!
- Other rewards include a LightSail t-shirt, a LightSail-gazing kit, a limited edition LightSail poster, and more — even a chance to send your name on the LightSail in 2016.
- "We want you to give the LightSail a kick ... to kickstart-it!" ##

## Lightsail Successfully Launched

20 May 2015 – [www.planetary.org/press-room/releases/2015/bill-nye-planetary-society.html](http://www.planetary.org/press-room/releases/2015/bill-nye-planetary-society.html)

Cape Canaveral, FL (May 20, 2015) – The Planetary Society's citizen-funded LightSail™ spacecraft has launched into orbit aboard a United Launch Alliance (ULA) Atlas V rocket from Cape Canaveral Air Force Station. The spacecraft is part of a secondary payload dubbed ULTRASat aboard the U.S. Air Force mission AFSPC-5. The mission will test LightSail's critical functions in low-Earth orbit, a precursor to a second mission set for 2016. [For full release, check online.]

### Bad News

27 May, 2015 – [www.space.com/29502-lightsail-solar-sail-software-glitch.html](http://www.space.com/29502-lightsail-solar-sail-software-glitch.html)

**Unfortunate followup Note:** This spacecraft has gone silent in Earth orbit, apparently victimized by a software glitch. LightSail stopped beaming data home on Friday (May 22), just two days after it blasted off along with the United States Air Force's robotic X-37B space plane.

"LightSail is likely now frozen, not unlike the way a desktop computer suddenly stops responding."

### Good News

1 June, 2015 – [www.space.com/29534-lightsail-solar-sail-reboots-after-glitch.html](http://www.space.com/29534-lightsail-solar-sail-reboots-after-glitch.html)

- A tiny satellite has recovered from an apparent software glitch in orbit and is on track to deploy its solar sail as early as June 2.
- The Planetary Society's [LightSail spacecraft went silent](#) on May 22, two days after launching on a mission designed to test solar-sailing technology.

- Repeated attempts to contact LightSail were unsuccessful, and mission team members said they might wait for a fast-moving particle to strike the small cubesat's electronics gear in just the right way.
- **"Our LightSail called home! It's alive!"**
- LightSail phoned home over the weekend, after having rebooted itself, just as engineers predicted.
- The spacecraft has been beaming data home and capturing test images.
- However, communications between LightSail and the ground remain spotty
- An attempt to upload a fix for the troublesome software failed.
- Instead, they aim to deploy the cubesat's 32 sq m (344-sq-ft) sail Tuesday, if possible. (The original plan was to perform this maneuver 28 days after launch.) ##

## LightSail wakes up again and deploys Solar Sail

7 June, 2015 - [www.space.com/29588-lightsail-spacecraft-deploys-solar-sail.html](http://www.space.com/29588-lightsail-spacecraft-deploys-solar-sail.html)

LightSail launched May 20 on a mission to prove out some key components of solar-sailing technology — for example, attitude-control and sail-deployment systems — ahead of a more involved sailing trial in Earth orbit next year with a different LightSail craft.

- The first flight has been a stressful and eventful one. The spacecraft stopped communicating with Earth after just two days in orbit, silenced by a software glitch.
- But LightSail rebooted a week later, recovering after a fast-moving charged particle slammed into its electronics board.
- LightSail went dark again on June 3; this time because of a battery.
- It bounced back again on June 6 and is now waving the shiny silver flag of sail-deployment success.
- The original plan, incidentally, called for putting LightSail through a 28-day orbital checkout period before attempting sail deployment. But after the spacecraft began experiencing problems, team members decided to deploy as soon as they could confidently do so.
- LightSail should now be visible from the ground, provided viewing conditions are good.
- To learn how to spot the cubesat, read Davis' latest mission update here: [/www.planetary.org/blogs/jason-davis/2015/20150607-lightsail-deployment-initiated.html](http://www.planetary.org/blogs/jason-davis/2015/20150607-lightsail-deployment-initiated.html)

## ROCKET TECHNOLOGY

### Is NASA Moving Toward a Hyperspace Drive?

4 May, 2015 - [www.space.com/29308-nasa-hyperspace-em-drive.html](http://www.space.com/29308-nasa-hyperspace-em-drive.html)

A group of NASA researchers has reportedly tested an electromagnetic (EM) propulsion drive that could potentially facilitate practical space travel in and around the Solar System.

#### 'Impossible' Space Engine May Actually Work: NASA

- The EM drive could take a spacecraft to the Moon in a matter of hours
- A trip to Mars could be cut to 70 days.
- The idea of an EM Drive isn't new — American, British and Chinese scientists have been investigating the concept for a while.
- The gist is to create a form of propulsion that doesn't require the use of propellant.
- Electromagnetic microwaves are bounced around a conical cavity and converted directly into thrust.
- The idea is also quite controversial, since it seems to violate certain Newtonian law of physics.
- Initial test results have come from both NASA and China's space agency..
- The significance of the new [research](#) is that NASA has successfully tested EM propulsion in a hard vacuum for the first time. Previous tests were conducted in atmospheric conditions.
- None of this [information](#) is coming from NASA directly, however.
- EM drive research is ongoing at several different agencies, those forums are legit, and sometimes news does leak out through unofficial channels. ##



## TO THE EDGE OF SPACE

### Private Dream Chaser Space Plane Could Land in Houston One Day

1 April, 2015 - [www.space.com/28990-dream-chaser-space-plane-houston-landing.html](http://www.space.com/28990-dream-chaser-space-plane-houston-landing.html)

- A privately built spacecraft shaped like a space shuttle could land at a conventional airport, according to its builder, the Sierra Nevada Corporation.
- Dream Chaser is expected to continue flight tests later this year



Artist's depiction shows Sierra Nevada's Dream Chaser spacecraft in orbit.

The shuttle-like spacecraft could land at a regular airport.

- It would use Ellington Airport's Spaceport in Houston as a landing site for the uncrewed version.
- This agreement with the Houston Airport System will lead to enabling all Dream Chaser variants to land in Houston, with the ability to return cargo and science to Houston directly from space,
- Sierra Nevada has been seriously contemplating using airports for Dream Chaser's landings since at least November, when it presented a study on the topic at the Space Traffic Management Conference at the Embry-Riddle Aeronautical University.
- Sierra Nevada has been seriously contemplating using airports for Dream Chaser's landings since at least November, when it presented a study on the topic at the Space Traffic Management Conference at the Embry-Riddle Aeronautical University.
- Sierra Nevada has been reviewing the applicable standards and unique requirements that must be addressed before such a landing could take place.
- Dream Chaser does not require any unique navigation or landing aids and its propellants aren't toxic.
- Dream Chaser was originally intended to ferry astronauts to and from the International Space Station, and the company received millions of dollars from NASA in competitive commercial crew agreements.
- So far, Dream Chaser has undergone several "captive carry" tests under an aircraft and a single glide test in 2013, when the prototype skidded off the runway due to a gear problem.
- The company plans to re-pitch Dream Chaser to NASA as a robotic spacecraft that could deliver cargo to the space station
- Another glide test is scheduled for later in 2015. ##

### Blue Origin to Launch Private Spaceship Test Flights This Year

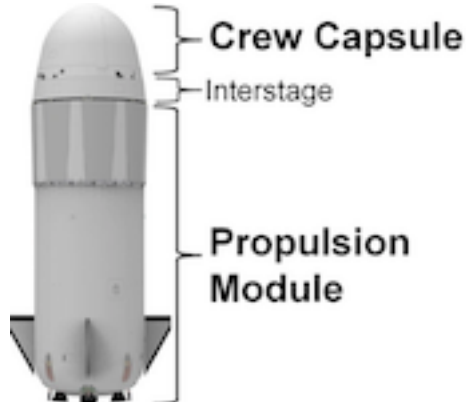
7 April, 2015 - [www.space.com/29044-blue-origin-new-shepard-spaceship-tests.html](http://www.space.com/29044-blue-origin-new-shepard-spaceship-tests.html)

[www.space.com/13672-blue-origins-vertical-rocket-takes-hop.html](http://www.space.com/13672-blue-origins-vertical-rocket-takes-hop.html)

Blue Origin's BE-3 rocket engine undergoes acceptance testing, generating its maximum 110,000-lbs of thrust, at the company's facility in West Texas.

Blue Origin, the secretive private spaceflight company founded by Amazon [CEO](#) Jeff Bezos, will begin suborbital flight tests this year of an innovative new spaceship — a milestone made possible by the firm's rocket engine success.

- The company will fly unmanned suborbital tests of its New Shepard spacecraft later in 2015.
- Shakedown cruises will test performance and reusability of the system's BE-3 rocket engine.
- Most likely the cruises will be later this year (2015)
- The spacecraft is designed to launch a crew capsule carrying at least three astronauts or passengers on suborbital flights over 100 km (62 mi) in altitude
- A reusable booster powered by the company's BE-3 rocket engine will launch from the company's West Texas proving grounds, and then return to make a land-based landing.
- Ultimately, Blue Origin aims to fly paying passengers & researchers on round trips to suborbital space.



**L:** A diagram of Blue Origin's **New Shepard** spacecraft for commercial spaceflight.

**R:** Blue Origin's BE-3 rocket engine undergoes acceptance testing, generating its maximum 110,000-lbs of thrust, at the company's facility in West Texas.

- Manned flights on New Shepard are still several years away.
- First, the spacecraft and its BE-3 engine must pass a rigorous testing regime.
- To achieve a vertical launch and vertical landing for New Shepard, the BE-3 rocket engine is capable of throttling up to 110,000 pounds of thrust, as well as back down to 20,000 pounds of thrust.
- The rocket engine is fueled by liquid hydrogen and liquid oxygen propellant and has passed 450 separate tests during its development.
- Blue Origin will make the BE-3 engine commercially available for vehicles other than its own
- The New Shepard vehicles are named in honor of Alan Shepard, the first American to reach space.
- The company is also developing an upper-stage variant of the BE-3 engine, called the BE-3U, for use on a future orbital vehicle.
- The company is also making progress on its next rocket engine: the BE-4.
- Blue Origin Has a partnership with the U.S.-based launch provider United Launch Alliance (ULA).
- Blue Origin is developing the BE-4 engine to power ULA's Next-Generation Launch Vehicle.
- The first tests of a BE-4 rocket engine should begin in 2016 and be complete by 2017.
- The company's orbital Space Vehicle project was one of several concepts competing under NASA's commercial crew program to fly astronauts to the International Space Station
- Blue Origin reported the loss of a prototype launch vehicle, but followed that in 2012 with the announcement of a successful crew capsule launch escape system test. ##

## United Launch Alliance Pulls Back Curtain on New Rocket

[www.planetary.org/blogs/jason-davis/2015/20150413-united-launch-alliance-vulcan-rocket.html](http://www.planetary.org/blogs/jason-davis/2015/20150413-united-launch-alliance-vulcan-rocket.html)

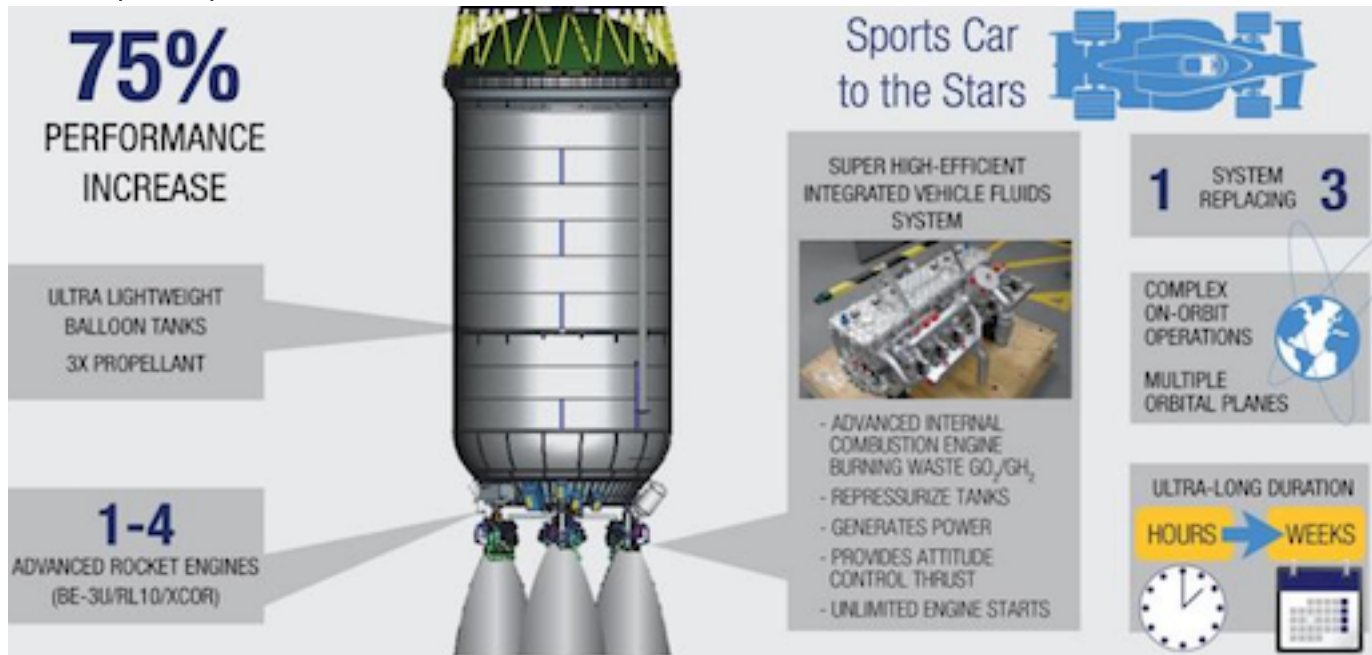
14 April, 2015 – United Launch Alliance unveiled its new launch system today, a mashup of its Atlas and Delta rockets the company says will increase power, lower costs and broaden mission capabilities.

- The name “**Vulcan**” won a ULA-led online election that drew more than one million votes.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

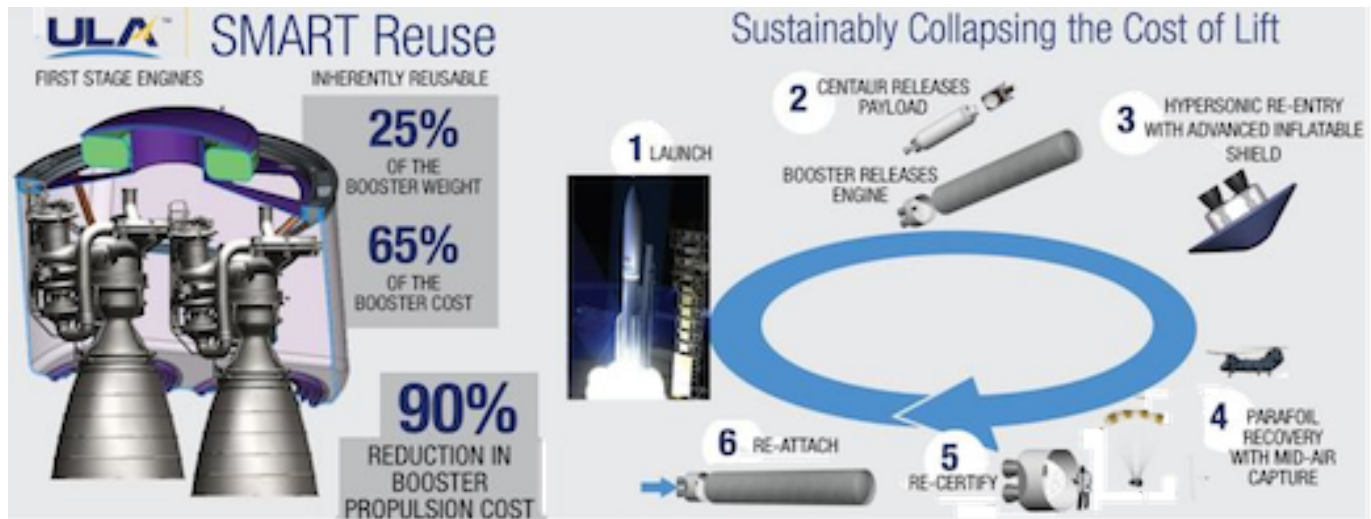
and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- Vulcan features a **supercharged booster with recoverable engines**, and a **new upper stage capable of recycling gaseous oxygen and hydrogen to power other subsystems**.
- Vulcan takes the best parts of Delta & Atlas and combines them with new and advanced technology.
- Vulcan's core stage is powered by a pair of **liquefied natural gas-fed Blue Origin BE-4 engines**.
- The move is part of a \o end reliance on Russian-built RD-180 engines, that power the Atlas V.
- Up to six solid rocket boosters can be added to Vulcan, one more than the five \on Atlas flights.
- Larger fuel tanks take advantage of dual BE-4s, producing up to 550,000 lbs of thrust each for a total of 1.1 million – vs. the 930,000 lbs from a single RD-180, which currently powering the Atlas V.
- The booster is a significant improvement in performance, and ia “conquerer of Earth’s gravity well.”
- ULA is also pursuing an Aerojet Rocketdyne-designed backup engine in the event Blue Origin runs into development problems.



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### Advanced Cryogenic Evolved Stage (ACES)

- The Vulcan rocket will initially be powered by a standard Centaur upper stage
- A replacement stage will **capture gaseous oxygen & hydrogen waste to power other subsystems.**
- Vulcan will initially fly with a Centaur upper stage.
- This allows ULA to transition its Atlas V launch manifest to Vulcan without disruption.
- Eventually, the Centaur will be replaced with ACES, the Advanced Cryogenic Evolved Stage.
- ACES runs on liquid hydrogen and liquid oxygen, and uses pressure-stabilized "balloon tanks" to lower weight and increase propellant capacity.
- The balloon tanks are so thin and lightweight that on Earth, they can't even support their own mass
- They would collapse without propellant or pressure in them to hold their shape.
- ACES could be powered by anywhere from one to four engines.
- ULA is currently looking at Aerojet Rocketdyne's RL-10, Blue Origin's BE-3, or an XCOR-built engine.
- A key part is the Integrated Vehicle Fluids System, which captures gaseous hydrogen and oxygen that would normally be vented into space, greatly increasing the stage's on-orbit lifetime.
- Captured propellant will re-pressurize the fuel tanks, generate electrical power and provide thrust for an attitude control system.
- ULA is touting the capability for its "Distributed Lift" system, in which an uphttp://www.collectspace.com/news/news-041315a-vulcan-rocket-ula-launch.htmlper stage lofts cargo a√nd propellant to low-Earth orbit, where it awaits the launch of a crewed spacecraft. ##

More at: [www.collectspace.com/news/news-041315a-vulcan-rocket-ula-launch.html](http://www.collectspace.com/news/news-041315a-vulcan-rocket-ula-launch.html)  
[www.space.com/29100-vulcan-rocket-united-launch-alliance.html](http://www.space.com/29100-vulcan-rocket-united-launch-alliance.html)

## Take a Ride Aboard Boeing's New Space Taxi – the CST-100

<https://www.youtube.com/user/Boeing?v=6VYIU9H3vM> (VIDEO)

## Paul Allen Launches 'Vulcan Aerospace' to Boost Private Space Travel

16 April, 2015 – [www.space.com/29117-vulcan-aerospace-paul-allen-private-spaceflight.html](http://www.space.com/29117-vulcan-aerospace-paul-allen-private-spaceflight.html)

Billionaire Paul Allen has formed a new company to help make spaceflight more affordable and efficient.



Inside Stratolaunch Systems' hangar in Mojave, California, where the company's huge carrier aircraft is coming together.

- Vulcan Aerospace is the company within Vulcan that plans and executes projects to shift how the world conceptualizes space travel through cost reduction and on-demand access,
- Vulcan Aerospace has its heritage in SpaceShipOne and oversees the **Stratolaunch Systems** project
- Stratolaunch's air-launch strategy should reduce costs and increase flexibility. Its ability to launch from variable locations will enable satellites and humans to be efficiently inserted into their most optimal orbit at a time of the customer's choosing
- Launching far away from populated areas (i.e. middle of the ocean) also significantly reduces public safety risk. Flexibility will be greater when the Stratolaunch system is adapted to launch various types of launch vehicles.
- The carrier vehicle is being developed by Scaled Composites; the launch vehicle by Vulcan Aerospace.
- The Stratolaunch carrier plane is on track to make its first test flight in 2016, next year. ##

## Launch, Land, Repeat: Reusable Rocket Technology Taking Flight

17 April, 2015 - [www.space.com/29131-reusable-rocket-technology-spacex-ula.html](http://www.space.com/29131-reusable-rocket-technology-spacex-ula.html)

### Reusable rockets aren't just a spaceflight pipe dream anymore.

- SpaceX performed another high-profile rocket reusability test April 14 during the launch of its Dragon cargo capsule toward the International Space Station (ISS). The first stage of the company's Falcon 9 rocket came back down to Earth and nearly pulled off a soft landing on an "autonomous spaceport drone ship" in the Atlantic Ocean.
- Falcon landed fine, but excess lateral velocity caused it to tip over post landing.
- SpaceX also tried such a rocket landing in January, during the launch of the previous Dragon cargo mission. The Falcon 9 hit its target, but came down too hard, exploding on the ship's deck.
- The California-based company will keep trying until it aces the drone-ship landings, and then it will keep pushing the envelope.
- SpaceX eventually aims to land its rockets on the ground, near their launch pads, so they can be inspected and outfitted for re-flight with a minimum of fuss and expense.
- Reusable rockets aren't just a spaceflight pipe dream anymore.
- It's all part of SpaceX's plan to slash the cost of spaceflight and open the heavens up to exploration.
- The implications are huge. This might change completely how we **approach** transportation to space.

### Others join the venture

- On April 13, **United Space Alliance (ULA)** announced that its next generation rocket "Vulcan" will feature reusable first stage engines.
- When the booster is done and finished with the rocket engines, ULA will cut them off and return them to the Earth using an advanced, inflatable, hypersonic heat shield. And then, with a very low, simplified logistics footprint, recover them in midair and return them to the factory to quickly recertify them, and then plop them under the next booster to fly.
- This will take up to 90% of the propulsion cost out of the booster."

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

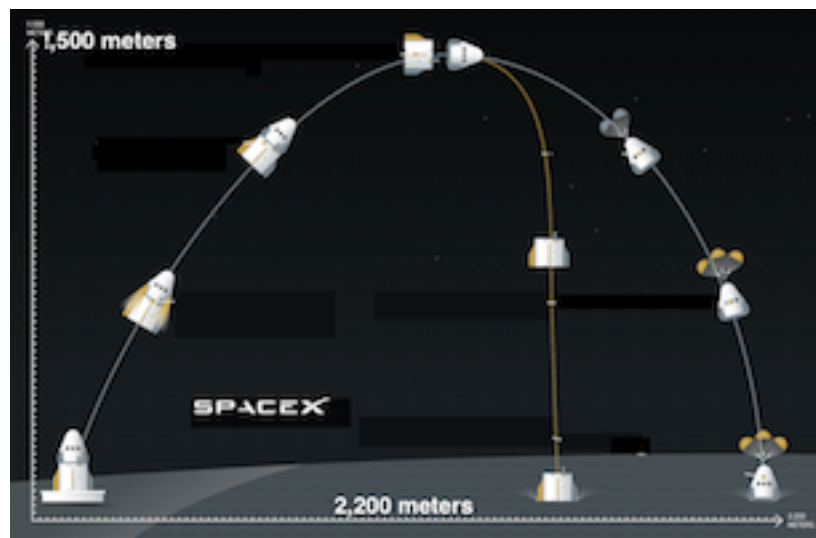
- Those first-stage engines will be BE-4s, built by the spaceflight firm Blue Origin.
- Headed by Amazon.com founder Jeff Bezos, Blue Origin is also working to develop its own reusable boosters that will come back to Earth in powered, vertical landings, then be refueled and reflight.
- Such rockets will help Blue Origin get astronauts to suborbital and orbital space, traveling aboard spacecraft known as New Shepard and the Space Vehicle.
- The suborbital New Shepard test flights will begin later in 2015.
- Virgin Galactic and XCOR Aerospace, are both developing reusable space planes — known as SpaceShipTwo and Lynx, respectively — to take paying passengers to suborbital space and back. ##

## SpaceX Demonstrates Astronaut Escape System for Crew Dragon Spacecraft

[www.nasa.gov/press-release/spacex-demonstrates-astronaut-escape-system-for-crew-dragon-spacecraft-0](http://www.nasa.gov/press-release/spacex-demonstrates-astronaut-escape-system-for-crew-dragon-spacecraft-0)

6 May, 2015 – A loud whoosh, faint smoke trail and billowing parachutes marked a successful demonstration by SpaceX of its Crew Dragon spacecraft abort system – an important step in NASA’s endeavor to rebuild America’s ability to launch crews to the International Space Station from U.S. soil.

- The successful test of the spacecraft’s launch escape capabilities proved the spacecraft’s ability to carry astronauts to safety in the unlikely event of a life-threatening situation on the launch pad.
- The Dragon crew fired its eight SuperDraco engines usly andleapt off a specially built platform at Cape Canaveral Air Force Station’s Space Launch Complex 40 in Florida.
- The engines fired for six seconds, producing about 15,000 pounds of thrust each and lifting the spacecraft out over the Ocean before jettisoning its trunk, and parachuting safely into the ocean.
- The test lasted about two minutes from engine ignition to splashdown.
- This is seen as a critical step toward ensuring crew safety for government and commercial endeavors in low-Earth orbit.



- The flight test furthers Space-X plan to meet a major requirement for the next generation of piloted spacecraft -- **an escape system that, in an emmegency abort, can quickly and safely take crew members away from their rocket while on the pad and through their ascent to orbit.**
- SpaceX will use the test data to help refine its aerodynamic and performance models, designed to help ensure crew safety throughout all phases of flight.
- Ths first test used a full-size spacecraft with a complete set of eight SuperDraco engines, designed for pad and launch use.
- The engine chambers burn hypergolic propellants monomethylhydrazine and nitrogen tetroxide.

- More than 270 special instruments, including temperature sensors and accelerometers, instruments that measure acceleration, were strategically placed in and around the vehicle to measure a variety of stresses and acceleration effects.
- A test dummy, equipped with sensors, went along for the ride to measure the effects on the human body. To further maximize the value of the test, weights were placed inside the capsule at crew seat locations to replicate the mass of a crewed launch.
- The trunk, an unpowered cylinder with stabilizing fins, detached from the spacecraft when it reached maximum altitude and fell back to Earth
- Meanwhile, the capsule rotated on as planned for a couple seconds before unfurling its drogue parachutes, which then deployed the main parachutes.
- Boat crews retrieved the Crew Dragon from the ocean and returned it to land for further analysis.
- The pad abort test is a payment milestone funded by the Commercial Crew Program under a partnership agreement established with the company in 2012.
- NASA awarded contracts last year to Boeing's CST-100 and SpaceX's Crew Dragon to build their respective systems for flight tests and operational missions to the space station
- Both should start flying crews to the Space Station in 2017.
- NASA already is preparing the space station for commercial crew spacecraft and the larger station 7-person crews that will be enabled by SpaceX's Crew Dragon and Boeing's CST-100.
- Each vehicle will carry as many as four astronauts each mission, increasing the station crew to seven and doubling the amount of science that can be performed off the Earth, for the Earth. ##

## SpaceX's Falcon 9 Rocket Certified for Military Launches

27 May, 2015 – [www.space.com/29496-spacex-rocket-military-launches-approval.html](http://www.space.com/29496-spacex-rocket-military-launches-approval.html)

- The U.S. Air Force has certified SpaceX's Falcon 9 rocket to launch military satellites, establishing a competitor to United Launch Alliance in the national security marketplace.
- The May 26 decision cleared the way for Space-X to bid for launching one of the Air Force's next-generation GPS 3 positioning, navigation and timing satellites.



- Denver-based ULA has had the U.S. national security launch market all to itself since it was created in 2006 through the merger of the rocket-making operations of Boeing and Lockheed Martin.
- The process entailed a thorough Air Force review of three successful Falcon 9 launches, the last of which took place in early 2014. Among the problems that delayed certification as identified in a March report by an independent panel was SpaceX's expectation that its successful track record was enough to win certification and the Air Force's push for design changes to the Falcon 9.
- The Air Force dedicated more than \$60 million and 150 people to the certification process.
- Certification involved 2,800 discrete tasks including verification of 160 payload interface requirements, 21 major subsystem reviews and 700 audits to establish a technical baseline.
- The Air Force had revised the agreement so that SpaceX could earn certification even with several issues outstanding provided it presents a mutually acceptable plan and schedule for resolving them.



- Open issues: SpaceX integrates satellites with its rockets horizontally, but the Air Force prefers vertical integration; SpaceX's planned addition of GPS-based launch vehicle tracking; information assurance; and secure flight termination.
- SpaceX is developing a much larger rocket called the Falcon Heavy expected to debut later this year.
- The newly certified Falcon 9 will compete against ULA's workhorse Atlas V, whose future availability is in question due to a congressional ban on the Russian-built engine that powers its first stage.
- ULA, which is phasing out its Delta IV rocket, hopes to field a new vehicle dubbed Vulcan around 2020 but continue launching Atlas Vs until around 2025. ##

### NASA Commercial Crew Partner SpaceX Achieves Pad Abort Milestone Approval

[www.nasa.gov/press-release/nasa-commercial-crew-partner-spacex-achieves-pad-abort-milestone-approval](http://www.nasa.gov/press-release/nasa-commercial-crew-partner-spacex-achieves-pad-abort-milestone-approval)

8 June, 2015 – NASA has approved a \$30 million milestone payment to Space-X under the agency's Commercial Crew Integrated Capability (CCiCap) agreement with the company following a recent and successful pad abort test of its Crew Dragon spacecraft.

- Data gathered during the test are critical to understanding the safety and performance of the Crew Dragon spacecraft and for certification for crew missions to ISS, and the ability to launch from the U.S.
- The Crew Dragon's eight SuperDraco engines fired on May 6 for about 6 seconds, each instantly producing about 15,000 pounds of thrust and lifting the spacecraft off a specially built platform at Cape Canaveral Air Force Station's Space Launch Complex 40 in Florida.
- The spacecraft traveled 1,187 m (3,561 ft) up before jettisoning its trunk and safely splashing down under three main parachutes in the Atlantic Ocean, 1,202 m (3,606 ft) from the launch pad.
- The reams of data collected provide designers with a real benchmark of how accurate their analyses and models are at predicting reality.
- The successful test of SpaceX's Crew Dragon launch escape capabilities demonstrated the spacecraft's ability to save astronauts in the unlikely event of a life-threatening situation on the launch pad.
- These steps ensure continued progress in the agency's effort to return to U.S. soil American crew launches to the International Space Station. SpaceX is expected to receive its authorization to proceed with work on a post-certification mission later this year. The determination of which company will fly the first mission to station will be made at a later time. ##

### SpaceX Narrowly Misses Rocket Landing After Dragon Spaceship Launch Success

14 April, 2015 – [www.space.com/29091-spacex-reusable-rocket-dragon-launch.html](http://www.space.com/29091-spacex-reusable-rocket-dragon-launch.html)  
[www.space.com/29119-spacex-reusable-rocket-landing-crash-video.html](http://www.space.com/29119-spacex-reusable-rocket-landing-crash-video.html)  
[www.space.com/29196-spacex-reusable-rocket-crash-throttle-valve.html](http://www.space.com/29196-spacex-reusable-rocket-crash-throttle-valve.html)

#### SpaceX's goal: Reusable rockets

- Developing fully and rapidly reusable rockets is a key priority for SpaceX and Musk.
- **“Such technology could slash the cost of spaceflight by a factor of 100.”**
- This was SpaceX second attempt.



The first stage of SpaceX's Falcon 9 rocket attempts to land on an unmanned ship in the

Atlantic Ocean on April 14, 2015. The rocket stage tipped over shortly after touching down.

- The previous try on Jan. 10, during the last Dragon launch; the Falcon 9 first stage came down on target that day as well, but hit the drone ship too hard and exploded on the deck as the rocket stage's stabilizing "grid fins" ran out of hydraulic fluid.
- SpaceX addressed that issue and also upgraded the drone ship.

#### Space cargo for the Station

- SpaceX holds a \$1.6 billion NASA contract to fly at least 12 resupply missions to the orbiting lab using Dragon and the Falcon 9; today's launch kicked off the sixth of those cargo missions.
- This trip, Dragon carried 1,950 kg (4,300 lbs) of food, scientific experiments and other supplies

#### Double Goal

- Dragon is the only cargo vessel currently flying that is made to survive the trip back to Earth. ##

### Why SpaceX Didn't Stick The Landing – But Soon Will | Video

[www.space.com/29767-why-spacex-didn-t-stick-the-landing-but-soon-will-video.html](http://www.space.com/29767-why-spacex-didn-t-stick-the-landing-but-soon-will-video.html)

### Airbus' Adeline Project Aims to Build Reusable Rockets & Space Tugs “more economical than Space-X Falcon 9”

[www.space.com/29620-airbus-adeline-reusable-rocket-space-tug.html](http://www.space.com/29620-airbus-adeline-reusable-rocket-space-tug.html)

10 June, 2015 – **Europe wants reusable rockets, too.**

European aerospace company Airbus has revealed its plans to develop

- 1) rocket engines that fly back to a runway and
  - 2) a reusable upper stage that acts as a space tug — reusability concepts that mirror those being developed by American spaceflight companies SpaceX and United Launch Alliance (ULA).
- Airbus has been working on its **Advanced Expendable Launcher INnovative engine Economy (Adeline)** reusable-rocket concept since 2010 and wants it to be up and running **by 2025**.
  - The technology could enable huge satellite constellations that would require a dramatic increase in the number of launches per year.

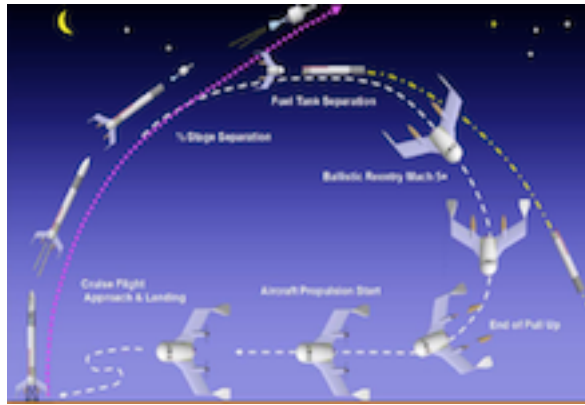


Artist's concept of Airbus' reusable Adeline craft coming in for a landing.

- As envisioned, Adeline detaches from its rocket's first-stage fuel tank and re-enters Earth's atmosphere at five times the speed of sound with its engines behind the wings and a heatshield.
- Once in the atmosphere, Adeline uses its wings to autonomously fly toward a runway and, once at subsonic speeds, uses deployable propellers to power its return, where it touches down on skids.
- Adeline is being proposed for the planned two-stage Ariane 6 rocket the European Space Agency is paying Airbus to develop. Ariane 6 could be flying in the 2020s.
- Adeline's engines use liquid fuel, such as kerosene and liquid oxygen, which other rockets also use, so Adeline could be used with other rockets.
- Airbus has become interested in reusability because it could help increase annual launch rates, which in turn would enable the lofting of enormous satellite networks.

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and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



How Airbus' reusable Adeline rocket system would work.

- Airbus sees in its landscape huge constellations that will need a drastic increase in launches per year."
- Airbus isn't the only company thinking this way. For example, SpaceX founder and CEO Elon Musk has spoken of launching a constellation of 4,000 broadband Internet satellites into low-Earth orbit (LEO). A company called OneWeb has plans for a 650-satellite network. Other LEO business proposals since the early 1990s have proposed large numbers of telecommunication and imaging satellites.

### Adeline vs. the Falcon 9

- Up to 80% of a rocket's cost is in its propulsion module, which can also contain the flight-control electronics. Airbus is predicting 30 % savings for its reusable system compared to existing rockets, as a result of reduced production costs.
- Airbus claims its concept is more cost-effective than SpaceX's ongoing effort to develop a Falcon 9 rocket with a reusable first stage.
- With Adeline, Airbus' partially reusable Ariane 6 would have a payload performance that is better than SpaceX's reusable Falcon 9. The first stage of the Falcon 9 releases its upper stage and then descends, engines first, to land vertically using legs that deploy outward from the sides of the stage. (The rocket's upper stage is expendable.)
- The Falcon 9 first stage needs 44 tons of propellant to reach a vertical landing site, and Adeline does not weigh as much.
- With a given launcher, Adeline's impact on payload performance, which for SpaceX is huge because it is a loss of 30–50 % of the mass of the payload for a given orbit — Airbus' loss will be much lower.
- Whereas SpaceX has been flight-testing its vertical landing system when launching customer payloads — and has twice nearly landed the Falcon 9 first stage on a floating platform in the Atlantic Ocean — Airbus has not yet developed the reusable rocket engine Adeline calls for.
- The company has made more progress with the deployable propellers, though.
- Airbus' patented the deployable propellers up to two years ago, and prototypes were wind-tunnel-tested six to eight months ago.
- The proof of concept has been done. This [deployable propeller] concept is now de-risked,
- Airbus engineers have also flown a scale-model version of Adeline for landing tests.

### Accommodating Adeline

- If Adeline is used the launch pad in French Guiana in South America, with the Ariane 6, that rocket's launch pad will need "very limited adaptations" to make room for the wings.
- Because Adeline's engines are protected by the heat shield on re-entry, their condition would be little different than those that have had a ground firing test as all rocket engines experience prior to launch.
- Whereas Adeline uses liquid fuel, Airbus' reusable upper stage/space tug concept employs electric propulsion and never returns to Earth.
- Electric propulsion involves accelerating electrically charged gas ions, typically xenon, using magnetic fields, requiring relatively long periods of time to accelerate a spacecraft to high speeds, compared to traditional chemical propulsion.
- The space tug would be left in orbit by the Ariane 6 and would be used "several times" to take payloads in LEO to a higher orbit.

- Each time the tug is used, an Ariane 6 second stage would rendezvous to deliver the payload and provide gaseous fuel resupply. Other rockets, not just Ariane 6, could use the tug. Once the tug's operational life comes to an end, it can be sent on a remote exploration mission.

**Editor:** *Space-X initial successes have encouraged others to also "think outside the box" and that is great!*

## NASA Issues Request for Proposals for New Class of Launch Services

[www.nasa.gov/press-release/nasa-issues-request-for-proposals-for-new-class-of-launch-services/](http://www.nasa.gov/press-release/nasa-issues-request-for-proposals-for-new-class-of-launch-services/)  
12 June, 2015 – NASA's Launch Services Program has issued a Request for Proposal (RFP) for **new commercial Venture Class Launch Services (VCLS) for small satellites**, often called **CubeSats** or **nanosatellites**, and experiments on science missions **using a class of rockets smaller than any currently available to the agency**.

- NASA plans to award one or more firm fixed-price VCLS contracts to accommodate 60 kg (132 lbs) of CubeSats in a single launch or two launches carrying 30 kg (66 lbs) each.
- The launch provider will determine launch location and date, but it must occur by April 15, 2018.
- At present, opportunities are mostly limited to ride-share type arrangements, when space is available
- NASA's Launch Services Program (LSP) seeks to encourage launch services dedicated to transporting smaller payloads into orbit.
- This effort is intended to demonstrate a dedicated launch capability for smaller payloads that NASA anticipates it will require on a recurring basis for future science and CubeSat missions.
- The services acquired under the RFP means NASA can buy the launch service as any other customer could and enjoy the savings since the rocket's costs are supported by a wide market of users.
- The boosters would be developed privately, and a single rocket would be able to send dozens of the tiny spacecraft into orbit at once on paths that best suit their scientific goals.
- Some of the tiny craft may even be sent beyond Earth orbit to send back reports from deep space.
- CubeSats already are used in the commercial sector for purposes, such as imagery collection and analysis, and are being used for operational purposes inot limited to research and development.
- This will open up viable commercial opportunities, and drive the costs down for everyone.
- The emerging uses are for data valuable to a number of industries including farming, shipping, data networking and the insurance field. "
- The drive comes as CubeSat designers learn how to build observatories capable of studying distant black holes and cosmic X-ray background to track geomagnetic storms of Earth's weather patterns.
- As we drive costs down, that frees up more money for science.
- The VCLS RFP is available at: <http://go.nasa.gov/1L2WUkM>

## SPACE STATION NEWS.

### Astronaut Hadfield to release first space album

15 April, 2015 – <http://phys.org/news/2015-04-astronaut-hadfield-space-album.html>

Recently retired Canadian astronaut Chris Hadfield, 55, is taking music to intergalactic heights with the first album written and recorded in space, to be launched later this year.





- Hatfield skyrocketed to stardom in 2013 with his take of David Bowie's "Space Oddity" performed with his guitar in the Space Station as he floated around in zero-G with tremendous grace.
- Hadfield, who retired as an astronaut in June 2013, had an acoustic guitar and a laptop during his stay aboard the International Space Station (ISS) from December 2012 to May 2013.
- "The guitar and vocal tracks were recorded in space—a human first."
- The album's fall 2015 launch underscores the importance that music has always had to Col. Hadfield whether he is in space or at home on Earth.
- The recording was an Internet sensation and has racked up more than 25 million views on YouTube.
- Do watch it at <https://www.youtube.com/watch?v=apemYk2oz7M>
- Hatfield has made a second career out of getting young people interested in space.

**Editor:** I've watched "Space Oddity" over and over and over - You will love it too!

## Russia to Launch National Orbital Space Station by 2023

[www.spacedaily.com/reports/Russia\\_to\\_Launch\\_National\\_Orbital\\_Space\\_Station\\_by\\_2023\\_999.html](http://www.spacedaily.com/reports/Russia_to_Launch_National_Orbital_Space_Station_by_2023_999.html)

17 April, 2015 – Russia's plan to build a new space outpost was confirmed December 2014, by the head of Roscosmos space agency at the time.

- The new space station would also serve as a base for Russia's lunar program.
- Planning a decade into the future is necessary.
- Russia actively participates in the use and maintenance of the International Space Station (ISS) in scientific and economic ways despite the fact that only 5% of Russian territory can be seen from the ISS.
- From the national station, of course, the whole territory of Russia will be visible.
- In February, Roscosmos said Russia will continue using the ISS until around 2024, and is planning to build its own orbital outpost using the existing ISS modules.
- Financing for Russia's federal space program through 2025 will be approximately \$40 billion ##

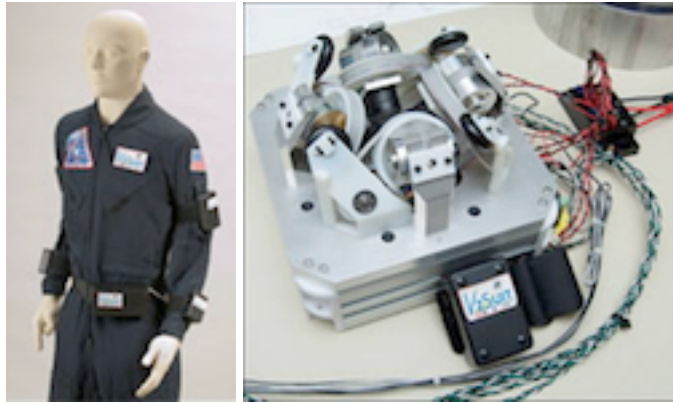
## Wearable Devices to Help Astronauts Find More Elbow Room in Space

30 April, 2015 – [www.space.com/29087-wearable-devices-track-astronauts-movements.html](http://www.space.com/29087-wearable-devices-track-astronauts-movements.html)

Things can be a little cramped when stuffed inside a spacecraft. Not only are your crewmates taking up room, but toss in supplies and lots of gear for good measure!

**If you are headed for Mars “elbow room” may be at a premium**

- The good news is that living and working in microgravity does create opportunities for astronauts to expand their environment because, as on the space station, they are not bound to a "floor."
- But NASA has yet to map how astronauts can use weightlessness to expand cabin useable area



**Right:** Draper Laboratory is applying technology developed to improve NASA's spacesuits to [help](#) the agency determine how to better design spacecraft habitats for long missions.

**Left:** Draper Laboratory is shrinking the control moment gyroscope shown above into wearable devices for astronauts.

- The habitable volume of the ISS is 13,696 cubic feet ... nearly that of a 2,000 square foot home. That's a lot of room up in space, and Draper's technology can help NASA determine how to better use it when designing future spacecraft.

### Location and Orientation

- Draper Laboratory in Cambridge, Massachusetts, to develop a [wearable device](#) that will track astronauts' location and orientation as they move around the International Space Station (ISS).
- From these devices, three dimensional models of the crew's use of the habitat can be created and validated. These models could inform and improve designs of future spacecraft to maximize the space astronauts have to [work](#).
- This is critical when plotting out any long duration exploration missions like planting footprints on the Red Planet.

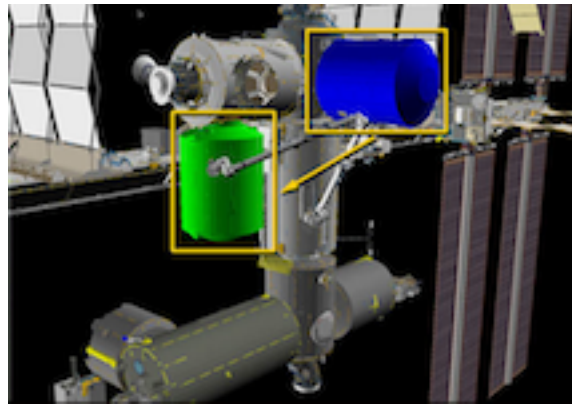
### Wearable prototype system

- Draper will deliver a wearable prototype system for NASA to test.
- This hardware incorporates **optical sensors to determine an astronaut's location** within ISS relative to other objects, as well as inertial measurement units (IMUs) and algorithms that, in an integrated system, can provide continuous information about movement and orientation.
- Earlier NIAC work developed spacesuit technology that introduces an artificial force similar to gravity to increase an astronaut's stability and health. ##

## ISS Module Relocation Makes Way for Commercial Crew Spacecraft

[www.nasa.gov/press-release/space-station-module-relocation-makes-way-for-commercial-crew-spacecraft](http://www.nasa.gov/press-release/space-station-module-relocation-makes-way-for-commercial-crew-spacecraft)

22 May, 2015 – The Space Station Program will take the next step in expanding a robust commercial market in low-Earth orbit when work continues, May 27, to prepare the the station for the future arrival of U.S. commercial crew and cargo vehicles.



The current location (blue) of the **Permanent Multipurpose Module (PMM)** on the Station and the location to which it will be repositioned (green) during the May 27 move.

- NASA is reconfiguring the station to create primary and back up docking ports for US commercial crew spacecraft being developed by Boeing and SpaceX to once again transport astronauts from U.S. soil to the space station and back beginning in 2017.
- The primary and backup docking ports also will be reconfigured for U.S. commercial spacecraft delivering research, supplies and cargo for the crew.
- Robotics flight controllers at the Mission Control Center at NASA's Johnson Space Center in Houston will detach the large Permanent Multipurpose Module (PMM), used as a supply depot on the orbital laboratory, from the Earth-facing port of the Unity module and robotically relocate it to the forward port of the Tranquility module.
- This move will clear the Unity port for its conversion into the spare berthing location for U.S. cargo spacecraft; the Earth-facing port on Harmony is the primary docking location. Harmony's space-facing port currently is the spare berthing location for cargo vehicles, freeing that location to be used in conjunction with Harmony's forward port as the arrival locations for commercial crew spacecraft.
- The transformation of Harmony's space-facing and forward ports for crew arrivals will continue later this year, when a pair of International Docking Adapters (IDAs) will be delivered on the seventh and ninth NASA-contracted SpaceX cargo resupply missions. The IDAs will be attached to Pressurized Mating Adapters 2 and 3, which enable the spacecraft to equalize internal pressure with the ISS.
- The PMM, originally named "Leonardo" by the Italian Space Agency that supervised its manufacture, was one of three cargo modules used to haul supplies back and forth from the station during space shuttle assembly missions.
- The PMM was launched for the last time to the station on the final flight of the shuttle Discovery on Feb. 24, 2011, and was installed on Unity five days later. The PMM is 22 feet long, 14 feet in diameter and weighs almost 11 tons, with an internal volume of more than 2,400 cubic feet. ##

## Boeing Space Capsule Gets NASA's 1st Commercial Crew Flight Order

1 June, 2015 - [www.space.com/29529-boeing-space-capsule-nasa-commercial-crew.html](http://www.space.com/29529-boeing-space-capsule-nasa-commercial-crew.html)  
<http://www.space.com/13309-cst-100-photos-boeing-private-space-capsule.html>

- NASA has awarded Boeing with the first order for a commercial crew change flight to the International Space Station once the company's new CST-100 space taxi is ready for manned flights in 2017.
- Both Boeing and SpaceX are building private spaceshipsto ferry astronauts on round trips to the space station for NASA. While SpaceX has not received an order yet, NASA said the company will likely receive one later this year.
- Who flies first will be determined at a later date.
- "Final development and certification are top priority for NASA and our commercial providers
- Having an eye on the future is equally important to the commercial crew and station programs.
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A Boeing CST-100 crew capsule approaches the International Space Station carrying a new crew for NASA for the first commercial crew flight, in 2017

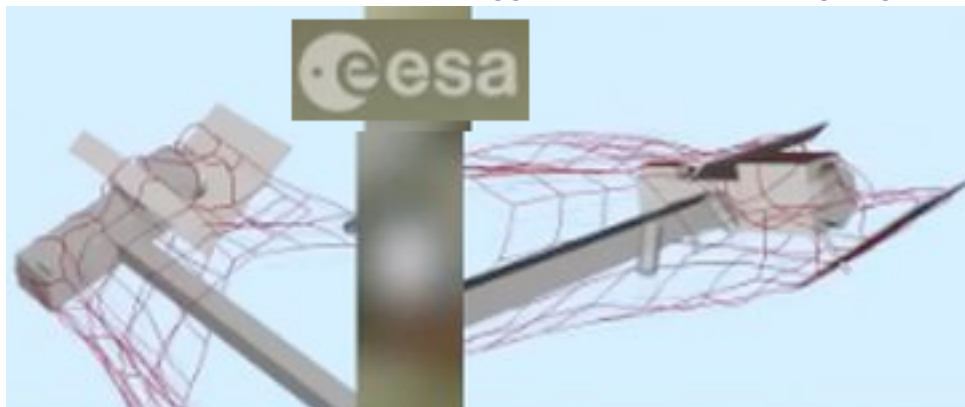
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- Who flies first will be determined at a later date.
- "Final development and certification are top priority for NASA and our commercial providers
- Having an eye on the future is equally important to the commercial crew and station programs.
- The milestone follows on from Boeing successfully finishing the fourth stage in its Commercial Crew Transportation Capability (CCtCap) contract with NASA.
- Boeing's spacecraft design is ready for assembly, integration and testing.
- =," said John Mulholland, Boeing's vice president of commercial programs, in a statement.
- For its part, SpaceX successfully launched an unpiloted pad abort test earlier this month.
- NASA makes its orders for CCtCap two or three years before the mission takes place, to give time for the companies to build the spacecraft.
- Boeing (and SpaceX, when its mission is awarded) will need to fully finish its certification before being allowed to fly the astronauts.
- Once the crew launches are running, a standard mission will see four crew members on board that are either from NASA or sponsored by NASA.
- The mission profile calls for the spacecraft to carry 1000 kg (220 lbs) of pressurized cargo and to remain docked to the station for up to 210 days. ##

## ORBITAL SPACE DEBRIS PROBLEM

### Fishing for Space Junk: New Nets Capture Old Satellites (Video)

10 April, 2015 - [www.space.com/29070-space-junk-fishing-net-video.html](http://www.space.com/29070-space-junk-fishing-net-video.html)

[www.space.com/29066-mock-satellite-snagged-by-net-on-zero-g-flight-video.html](http://www.space.com/29066-mock-satellite-snagged-by-net-on-zero-g-flight-video.html)





### The European Space Agency has gone fishin' — for space junk

- Scientists hoping to remove old hardware from orbit around Earth have gone on a "fishing" trip .
- They are free-falling through the air, shooting nets at a miniature model satellite.
- Watch the video of the space fishing attempt on Space.com.
- The trip is aboard an airplane that flies in a parabolic shape, causing brief periods of weightlessness.
- The flight was meant to test the ability of a "fishing net" to capture and remove dead satellites, rocket parts and other man-made debris floating in space. ##

## Space Junk Menace Becomes a Gamer's Dilemma in 'Habitat'

19 April, 2015 - [www.space.com/29094-space-junk-habitat-game.html](http://www.space.com/29094-space-junk-habitat-game.html)

For more information on Habitat, go to: <http://www.jointhe509th.com>



### Orbital debris is a menace – that's a fact.

How to de-clutter space from human made junk is an on-going concern by numbers of countries.

#### Space nets, laser blasts, garbage scows, giant foam balls:

These and other techniques have been proposed to deal with space junk. One imaginative solution to pollution can be found in "Habitat," a **space-theme strategy game** that places you in high orbit around a ravaged Earth far in the future.

#### Seven Wild Ideas [ [www.space.com/24895-space-junk-wild-clean-up-concepts.html](http://www.space.com/24895-space-junk-wild-clean-up-concepts.html) ]

1. Knock Junk Down with a Net
  2. Huffing and Puffing
  3. Solar Sail
  4. Space Debris Slingshot
  5. Electricity
  6. Pushing Debris out into Space
  7. Snagging and Moving
- **"Habitat" is a physics-based space survival game** where you build, fly, and fight with stations you assemble out of space debris.
  - Your survival depends on your ability to sift through centuries of floating space junk to construct a sustainable base."
  - Upgrade and arm your creations with weapons and structures you find in orbit, fly and explore using rocket physics, and do battle with deadly enemies to save humanity
  - This is a **space survival game** where crisis is guaranteed and your only chance for survival is to be creative and decisive in the face of disaster.
  - Leading your team of engineers, you will have to build and fly your space stations in a zero G setting, Mastering physics driven flight simulation to explore the space around you.
  - To thrive and grow you have to manage your population and their environment.
  - If threatened, get creative and turn your space stations into deadly weapons using pieces of debris you pick up such as rockets, lasers and particle accelerators to fight and ultimately survive against attacks from the enemy." ##

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

## New 'space trash' laser may tidy up Earth's orbit

[www.spacedaily.com/reports/New\\_Space\\_Trash\\_Laser\\_May\\_Tidy\\_Up\\_Earths\\_Orbit\\_999.html](http://www.spacedaily.com/reports/New_Space_Trash_Laser_May_Tidy_Up_Earths_Orbit_999.html)

23 April, 2015 – A new combination telescope–laser is currently in development, to combat the growing issue of space trash – debris released into Earth's orbit from human activities in the solar system.

- An international team of scientists has put forth a proposal that combines a **super-wide field-of-view telescope** developed by RIKEN's EUSO team, with the **ability to detect celestial objects**, and a **high-efficiency laser that will track down and remove the debris from orbit**.



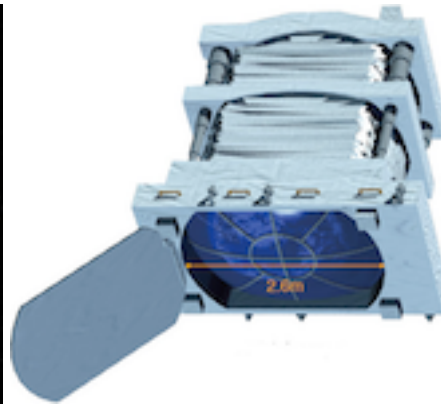
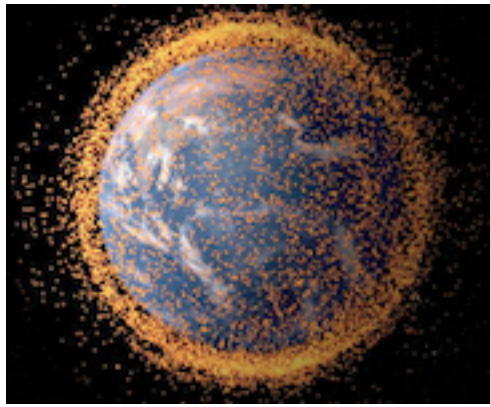
The EUSO telescope will first detect the debris, then the laser will produce a high-velocity plasma blast that will reduce the orbital velocity, causing the object to fall and burn up in Earth's atmosphere

**VIDEO:** [https://www.youtube.com/watch?v=tN\\_CvGJKMOI](https://www.youtube.com/watch?v=tN_CvGJKMOI)

- The EUSO telescope was originally planned to detect ultraviolet light emitted from air showers produced by ultra-high energy cosmic rays entering the atmosphere at night.
- **EUSO's wide field of view and powerful optics** could be adapted too the new mission of detecting high-velocity debris in orbit near the ISS."
- The ever-accumulating space debris consists of a **huge variety of artificial objects orbiting Earth**.
- Over the last 15 years, the amount of these objects has nearly doubled.
- It now has presents itself as an issue for further development in space.
- The total amount is about 3,000 tons of **old satellites, rocket bodies, and spare & discarded parts**.
- It occasionally collides with various spatial infrastructure such as the International Space Station.
- The debris exists at different orbits, making it all the more difficult to eliminate, but this new device may change things.
- The EUSO telescope will detect the debris, then **the laser will produce a high-velocity plasma blast to reduce the orbital velocity, causing the object to fall and burn up in Earth's atmosphere**.
- The plan is to **deploy a scale model, a "proof of concept" experiment, aboard the ISS**
- If all goes well the researchers will install a full-scale version.
- This proposal is radically different form the more conventional ground-based approach
- It should be a more manageable approach that will be accurate, fast, and cheap.
- This could be a way to stop the rapidly growing space debris endangering space activities.
- This dedicated system could remove most of the centimeter-sized debris within 5 years. ##

## Space Station Could Get Laser Cannon to Destroy Orbital Debris

30 April, 2015 – [www.space.com/29271-space-station-laser-cannon-orbital-debris.html](http://www.space.com/29271-space-station-laser-cannon-orbital-debris.html)



**Left:** The Extreme Universe Space Observatory telescope, originally built to detect cosmic rays from the Space Station, could be used to detect potentially dangerous debris in orbit

### Protecting ISS and spacecraft from orbiting debris

- TheSpace Station could one day get armed with a laser to shoot down orbiting debris.
- A laser-firing satellite might get rid of a large % of the most troublesome space junk orbiting Earth.
- Nearly 3,000 tons of space debris reside in low-Earth orbit: derelict satellites, rocket bodies and parts and tiny bits of wreckage produced by collisions involving larger objects.
- Impacts from pieces of junk that are only the size of screws can still inflict catastrophic damage on satellites, since these projectiles can travel at speeds on the order of 36,000 km/h (22,370 mph).
- The problem is growing as more satellites and spacecraft are put up.

### Chain Reactions magnify the problem

- Large pieces of junk can generate lots of small fragments if they get hit, and those fragments can then go on to strike other objects in orbit for a chain reaction of destruction.
- ISS and most satellites can handle impacts by debris smaller than 1 cm (4 in) with adequate shielding.
- However, ground-based radar and computer models suggest that more than 700,000 pieces of debris larger than 0.4 inches now orbit Earth.
- Items larger than 10 cm (4 in) are big enough to spot, debris between 1–10 cm (0.4–4 in) in size is significantly more difficult to identify and dodge.
- The **Extreme Universe Space Observatory (EUSO)**, to be installed on Japan's Kibo ISDS module in 2017, although originally designed to detect cosmic rays, could help detect dangerous debris.
- A powerful laser under development could then help shoot down this space junk.
- Once EUSO detects incoming a threatening object, a Coherent Amplification Network (CAN) laser can blast the debris. The CAN lconsists of many small lasers to generate a single powerful beam.
- This device is currently under development to drive particles at high speeds in atom smashers.
- The laser would vaporize a thin film off the surface of debris. The resulting high-speed plasma would act like a rocket plume, nudging the junk downward, away from ISS to burn up in Earth's atmosphere.
- A full-scale version of their system would be armed with a 100,000-watt ultraviolet CAN laser that can fire 10,000 pulses per second, each lasting one-tenth of one-billionth of a second.
- This laser would need c. 8 kg (17 lbs) of lithium-ion batteries to blast debris from 100 km (60 m).
- The plan is to deploy a small proof-of-concept version of the system ISS, to consist of a miniature version of EUSO and a prototype 10-watt ultraviolet CAN laser firing 100 pulses per second.
- The mini-EUSO telescope has been accepted as a project on the ISS for 2017 or 2018
- But the laser system is still a concept that has not been built. ##

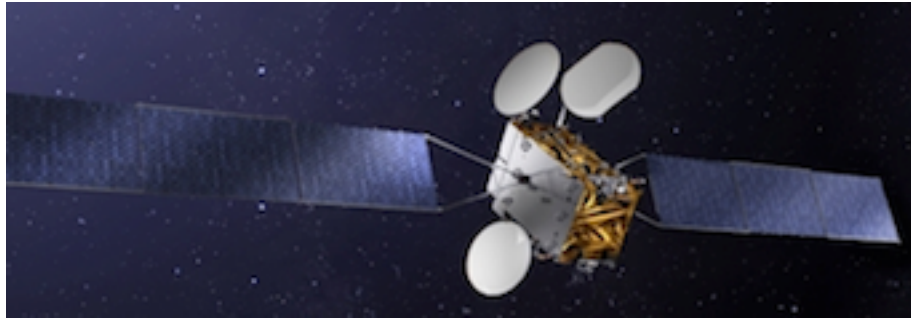
## LOW EARTH ORBIT

## MISSION TO PLANET EARTH

## SpaceX Falcon 9 Rocket Launches Turkmenistan's First-Ever Satellite

27 April, 2015 – [www.space.com/29229-spacex-launches-turkmenistan-satellite.html](http://www.space.com/29229-spacex-launches-turkmenistan-satellite.html)

The private spaceflight company SpaceX launched the first-ever satellite for Turkmenistan into orbit April 27th, marking the 2nd space mission in less than two weeks for the firm's Falcon 9 rocket.



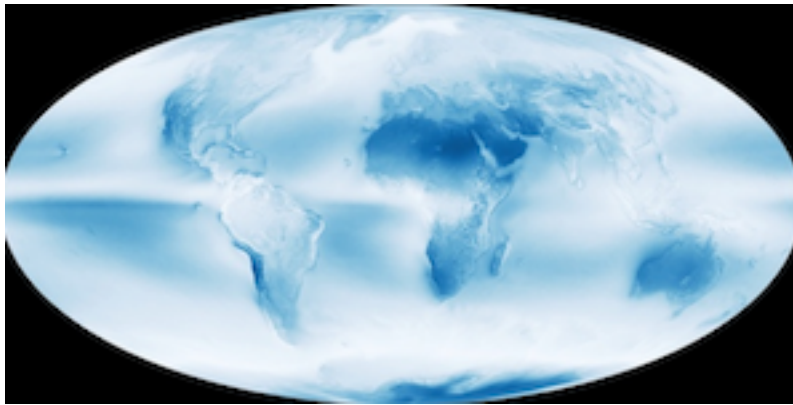
Turkmenistan (once a republic of the former Soviet Union) – <http://en.wikipedia.org/wiki/Turkmenistan>

- The **TurkmenÄlem52E/MonacoSat communications satellite** is in geo[stationary] transfer orbit.
- The satellite, which was built by France-based aerospace firm **Thales Alenia Space**
- It weighs about 4,500 kg (9,920 lb) and has a design lifetime of 15 years.
- The spacecraft will be operated by the Turkmenistan Ministry of Communications
- Its observation area includes **Europe, Central Asia and Africa**.
- The satellite will allow Turkmenistan to operate its first **national satellite telecommunications system**, ensuring enhanced, secure telecommunications for the country,
- The rocket launch was SpaceX's 5th mission of 2015, and the 2nd in less than two weeks.
- SpaceX did not attempt a landing on the drone ship during this launch.
- The next attempt will come on the next Dragon cargo launch, currently scheduled for June 19<sup>th</sup>. ##

## Cloudiest Places on Earth Revealed in Stunning New Image

13 May, 2015 – [www.space.com/29403-cloudiest-places-on-earth-nasa-image.htm](http://www.space.com/29403-cloudiest-places-on-earth-nasa-image.htm)





The blue-and-white image averages daily cloud observations from the satellite between July 2002 and April 2015. It reveals a mostly hazy Earth with three especially cloudy zones.

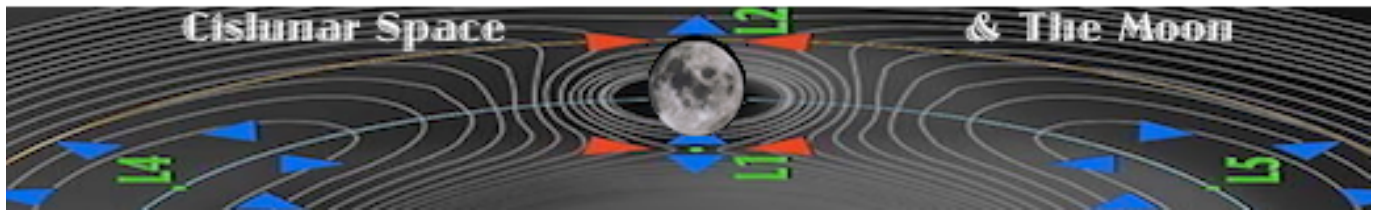
- An average of all of NASA Aqua satellite's cloud observations between July 2002 and April 2015 can be seen in this image, where colors range from **dark blue (no clouds)** to **white (lots of clouds)** .
- A new NASA image shows Earth to be a cloudy world**
- **Clouds cover about 67% of the Earth's surface at any given time,**
  - **Less than 10% of the skies over the ocean are sunny and blue.**
  - A decade's worth of data from the **Moderate Resolution Imaging Spectroradiometer (MODIS)** on NASA's **Aqua satellite** reveals **where clouds gather** and **where skies tend to be clear.**
  - These **zones are linked to the global circulation patterns** in Earth's atmosphere.
  - In the mid-latitudes, polar air masses collide with Ferrel cells, which circulate air westward at high altitudes and eastward at the surface. These patterns cause air to rise around 60° north and south of the equator, promoting the formation of clouds in these two zones. These same patterns push air downward between 15° and 30° from the equator, resulting in the cloud-free zones seen in desert areas such as Australia and northern Africa.
  - The third particularly cloudy zone is found over the equator, where "Hadley" circulation cells dominate. In these zones, warm air rises and condenses, creating both clouds and storms.,
  - On the satellite image, cloudy zones are in bright white; the bluer the region, the clearer the skies. ##



### 'Roomy' Blue Origin Capsule Provides Incredible Space Tourist Experience

[www.space.com/29709-roomy-blue-origin-capsule-provides-incredible-space-tourist-experience-animation.html](http://www.space.com/29709-roomy-blue-origin-capsule-provides-incredible-space-tourist-experience-animation.html)





## CISLUNAR SPACE

## THE MOON

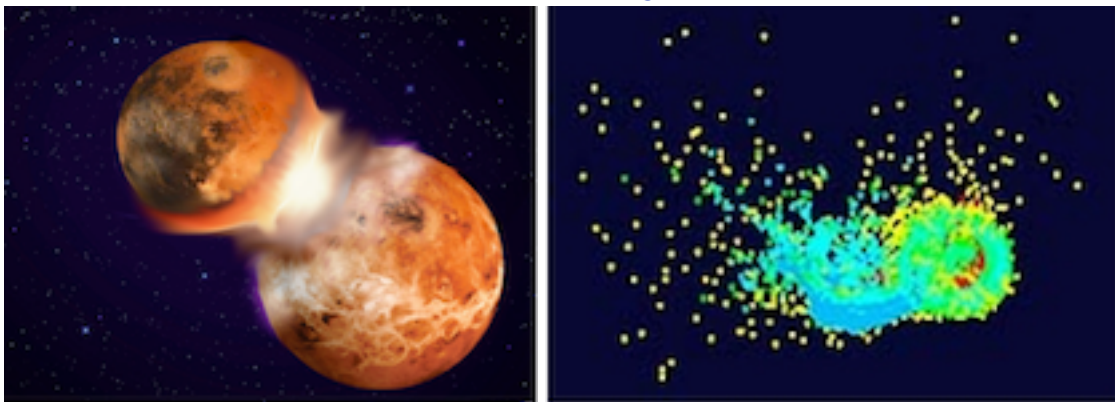
We insist on capitalizing “Moon” when it refers to Earth’s satellite. Read why:  
<http://www.moonsociety.org/info/capital-M-for-Moon.html>

## How the Moon Formed: Violent Cosmic Crash Theory Gets Double Boost

8 April, 2015 – [www.space.com/29047-how-moon-formed-earth-collision-theory.html](http://www.space.com/29047-how-moon-formed-earth-collision-theory.html)

Also –

[www.space-travel.com/reports/Moon\\_formed\\_when\\_young\\_Earth\\_and\\_little\\_sister\\_collided\\_999.html](http://www.space-travel.com/reports/Moon_formed_when_young_Earth_and_little_sister_collided_999.html)



These images depicts the catastrophic collision of two planetary bodies similar in composition that led to the formation of the Earth and the Moon 4.5 billion years ago

- The formation of the Moon has long remained a mystery, but new studies support the theory that it formed from debris left from a collision between the newborn Earth and a Mars-size rock.
- Earth was born about 4.5 billion years ago, and scientists think the Moon arose a short time later.
- The leading explanation of the Moon’s origin, the “Giant Impact Hypothesis,” was proposed in the 1970
- It suggests the Moon resulted from the collision of two protoplanets, the just-forming Earth, and a Mars-size object called Theia. The Moon then coalesced from the debris.
- Long-standing challenges to this scenario are rooted in the Moon’s chemistry. Most models of the giant-impact theory say that more than 60% of the Moon should be made of material from Theia.
- The problem is that most bodies in the solar system have unique chemical makeups, so that Earth, Theia and the Moon should as well. But rock samples from the Moon re puzzlingly more similar to Earth than such models would predict when it comes to **versions of elements called isotopes**.
- In terms of composition, Earth and the Moon are almost twins, their compositions differing by at most few parts in a million. This contradiction has cast a long shadow on the giant-impact model.

### The Moon's violent birth

- To shed light on this mystery, scientists simulated collisions in the early solar system of between 85 to 90 protoplanets — each up to 10 % of Earth's mass, — and 1,000 to 2,000 smaller “planetesimals.”
- Each of the latter had masses about 0.25 %of Earth's.
- Each simulation typically produced 3>4 rocky planets, the largest bcomparable to Earth's mass.

- These worlds often were composed of material distinct from one another. However, **20–40 % of the time, the composition of one planet was very similar to the makeup of the last protoplanet that had collided with it. This likelihood is about 10 times higher than previous estimates.**
- Compositionally similar planet–impactor pairs are not rare at all.
- Similarity in composition has to do with the orbits occupied by these colliding bodies.
- The composition of these objects varied with the amount of heat they received — the farther away from the Sun, the colder it was, and the more likely to retain a relatively heavy isotope of oxygen.
- As each planet assembled, the last protoplanet to collide with it probably shared a similar orbit.
- Thus, protoplanets that share similar birthplaces can also share a similar composition.
- This suggests that the similar composition of the Earth and Moon could be a natural consequence of a giant impact. This explains why their compositions differ from that of other bodies in the solar system

### A moon made of Earth

- Another puzzle in how the Moon and Earth were formed has to do with tungsten, a metal with highly siderophile characteristics – it binds tightly with iron, and it would have a strong tendency to move into Earth's iron–rich **core**. But Earth's **crust and mantle** have an excess of elements like tungsten.
- Prior research suggests that the iron–loving elements seen on Earth come mainly from a "late veneer" of material that accumulated both after the Moon–forming impact and after Earth's core had formed. If this theory is true, then Earth's tungsten isotope levels should be different from those on the Moon.
- Another two independent studies reveal there is indeed this predicted difference between the amount of tungsten isotopes on Earth and on the Moon.
- Scientists analyzing lunar rocks discovered an excess in the abundance of the isotope tungsten–182 on the moon compared with the present–day Earth's mantle.
- This is the first time that we can resolve such a small difference.
- This difference is best explained by the theory that differing proportions of tungsten–182 accumulated after the Moon–forming impact, giving independent evidence for the late–veneer hypothesis, ##

## Moon–forming impact left scars in distant asteroids

17 April, 2015 – <http://www.sciencemag.org/content/348/6232/271>

“Not too long after the planets began forming, a Mars–sized object slammed into Earth, creating the debris that would coalesce into the Moon.

- Some of the debris escaped all the way out to the asteroid belt.
- Collisions there left shock–heating signatures that can still be detected billions of years later in meteorites that have fallen to Earth.
- A significant number of these altered meteorites have **ages clustering at 105 million years after the solar system's birth**—the true age of the Moon–forming impact,.
- The result is an independent check on different estimates for the Moon's age
- The asteroid belt could be witness to other ancient disruptions in the inner solar system. ##

**Note:** to read the full article, you must join/subscribe to Science Magazine.

## Crashing Comets may explain mysterious Lunar Swirls

[www.space-travel.com/reports/Crashing\\_comets\\_may\\_explain\\_mysterious\\_lunar\\_swirls\\_999.html](http://www.space-travel.com/reports/Crashing_comets_may_explain_mysterious_lunar_swirls_999.html)

3 June, 2015 – Brown University researchers have produced new evidence that lunar swirls – wispy bright regions scattered on the Moon's surface – were created by comet collisions in the last 100 million years.

- State–of–the–art computer models were used to simulate the dynamics of comet impacts on the lunar soil. They suggest that such impacts can account for many of the features in the mysterious swirls.
- Lunar swirls have been the source of debate for years. The twisting, swirling streaks of bright soil stretch, in some cases, for thousands of miles across the lunar surface.
- Most are found on the unseen far side of the Moon
- But one famous swirl called **Reiner Gamma** can be seen by telescope on the SW corner of the nearside.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- At first glance, the swirls do not appear to be related to large impact craters or any other topography. They simply look as if someone had finger-painted the surface. There has been an intense debate about what causes these features.



A closer look at the Reiner Gamma. Image courtesy of NASA/Lunar Reconnaissance Orbiter.

- In the 1970s, scientists noted that many of the swirls were associated with anomalies of the Moon's crustal magnetic field. That led to one hypothesis for how the swirls may have formed. Rocks below the surface in those spots might contain remanent magnetism from early in the Moon's history, when its magnetic field was much stronger than it is now.
- It had been proposed that those strong, locally trapped magnetic fields deflect the onslaught of the solar wind, which was thought to slowly darken the Moon's surface. The swirls would remain brighter than the surrounding soil because of those magnetic shields.
- A different idea for how the swirls may form has its roots in watching the lunar modules land on the Moon during the Apollo program.
- The whole area around the lunar modules was smooth and bright because of the gas from the engines scoured the surface. That led one researcher to wonder if comet impacts could cause the swirls.
- Comets carry their own gaseous atmosphere called a coma. When small comets slam into the Moon's surface – as they occasionally do – the coma may scour away loose soil from the surface, not unlike the gas from the lunar modules. That scouring may produce the bright swirls.
- A paper outlining the idea in the journal Nature in 1980 focused on how the scouring of the delicate upper layer of lunar soils could produce brightness consistent with the swirls. The structure of the grains in the upper layer (termed the 'fairy castle structure' because of the way grains stick together) scatters the sun's rays, causing a dimmer and darker appearance.
- When this structure is stripped away, the remaining smoothed surface would be brighter than unaffected areas, especially when the sun's rays strike it at certain angles. For Reiner Gamma on the lunar nearside, those areas appear brightest during the crescent moon just before sunrise.
- As computer simulations of impact dynamics improved, researchers took a second look at whether comet impacts could produce that kind of scouring. New simulations showed that the impact of a **comet coma plus its icy core** would blow away the smallest grains atop the lunar soil.
- The scoured area would stretch for perhaps thousands of kilometers from the impact point, consistent with the swirling streaks that extend across the Moon's surface. Eddies and vortices created by the gaseous impact would explain the swirls' twisty, sinuous appearance.
- The comet impact hypothesis could also explain the presence of magnetic anomalies near the swirls/
- The simulations showed that a comet impact would melt some of the tiny iron-rich particles near the surface. When they cooled, they record any magnetic field that may be present at the time.
- Comets carry with them a magnetic field created by streaming charged particles that interact with the solar wind. As the gas collides with the lunar surface, the cometary magnetic field becomes amplified and recorded in the small particles when they cool.
- Taken together, the results offer a more complete picture of how the swirls form: the first time anyone has looked at this using modern computational techniques.
- Everything we see in simulations of comet impacts is consistent with the swirls as we see them on the moon. This process provides a consistent explanation.
- New Moon missions could finally resolve the debate.

**Related Story:** [www.space-travel.com/reports/Moon\\_engulfed\\_in\\_permanent\\_lopsided\\_dust\\_cloud\\_999.html](http://www.space-travel.com/reports/Moon_engulfed_in_permanent_lopsided_dust_cloud_999.html)

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## MOON – UNMANNED MISSIONS

### Yutu finds Moon still active in old age

19 April, 2015 – [www.space-travel.com/reports/Yutu\\_finds\\_Moon\\_still\\_active\\_in\\_old\\_age\\_999.html](http://www.space-travel.com/reports/Yutu_finds_Moon_still_active_in_old_age_999.html)

Findings from China's first Moon rover Yutu, or Jade Rabbit, the only scientific probe to land on the Moon in almost 40 years, are rewriting lunar history.



- Analyzing data sent back from Yutu, scientists find that a large volcanic eruption happened at its landing site, a basin called Mare Imbrium, about 2.5 billion years ago.
- Previously it was believed the Moon had seen little geological activity since 3.1 billion years ago, while the Earth is now in its adulthood, and quite active.
- On December 14, 2013, the Chang'e 3 lunar craft and Yutu rover performed a soft landing in the northeast of the Mare Imbrium, on the nearside of the Moon.
- Yutu encountered operational difficulties after moving just 114 meters, it gathered some useful data.

#### Volcanic Mystery

- The Moon's surface has many large basins caused by asteroid bombardment c. 3.9 billion years ago.
- These basins were filled with dark basalt lava flows from volcanic eruptions, 3.8–3.1 billion years ago.
- The eruptions produced layer after layer of basalt stacked vertically, hiding the history of the Moon.
- The Yutu carries lunar penetrating radar (LPR) to help see below the surface.
- The LPR data indicates three underlying basalt layers measuring 195, 30, and 130 meters from the top at the Mare Imbrium.
- That shows the upmost layer of the basalt is quite thick.
- Satellite images show the upmost layer of basalt is large and dates back to 2.5 billion years ago.
- For the Moon, 2.5 billion years ago was its late years in terms of geological activity
- The data shows that a very large volume of basalt lava erupted at that time.

#### Thicker Lunar Soil

- Using LPR, Yutu carried out the first in-situ measurement of the thickness of the lunar regolith layer, about 5 meters deep, significantly deeper than expected for a young mare sites.
- In the highlands, soil thickness was c. 2–4 m (6.5–13 ft)
- In the mare, up to 8–16 m (26–52 ft) in the highlands.
- The thickness of the lunar regolith layer appears to have been underestimated.
- Many important resources such as helium-3, a promising future energy source, are in the lunar soil.
- Spectral analysis showed the soil beneath Yutu has similar mineral contents to the lunar soil samples taken back to the Earth by the U.S. Apollo missions.
- Chinese scientists detected 12 elements, including four trace elements in the lunar soil.
- They also found higher iron oxide (FeO) and titanium dioxide (TiO<sub>2</sub>) concentrations and lower aluminum oxide (Al<sub>2</sub>O) concentrations than in the samples collected by the U.S. and Soviet lunar missions.
- These findings suggest a new type of basalt beneath, which has not yet been sampled.

### New Evidence

- Another important finding related to KREEP (potassium, rare earth elements and phosphorus), a special geochemical component on the Moon, is related to the origins of the Moon from debris of a collision of Earth and a "Mars-sized object" now named Theia.
- Given the energy generated by this collision, it has been deduced that a large part of the Moon would have been liquefied, and this formed a lunar magma ocean.
- As the melt crystallized, heavy minerals such as olivine and pyroxene precipitated and sank to the bottom to form the lunar mantle.
- The material anorthosite plagioclase floated because of its low density, forming a solid crust. Elements that are usually incompatible would have been progressively concentrated into the residual magma. Thus a KREEP-rich magma was formed between the crust and mantle.
- Lin says data from Yutu show that the basalt beneath the rover contains 10 to 20 % KREEP substances.
- These substances were added to the basalt when the lava erupted through the KREEP-rich layer.
- The finding is new evidence supporting the lunar magma ocean hypothesis.
- The Yutu Moon probe will help in understanding the early history of the Earth. \.
- The Earth and the Moon share similar experiences in their origins.
- **The early history of the Earth, which has been erased in the frequent geological activity, can be studied on the Moon. ##**

## China Plans First Ever Landing On The Lunar Far Side

[www.spacedaily.com/reports/China\\_Plans\\_First\\_Ever\\_Landing\\_on\\_the\\_Dark\\_Side\\_of\\_the\\_Moon\\_999.html](http://www.spacedaily.com/reports/China_Plans_First_Ever_Landing_on_the_Dark_Side_of_the_Moon_999.html)

22 May, 2015 – What lies on the farside of the Moon? China's on the case, launching the first expedition of its kind, a journey to the Moon's back side..

- Chang'e is the Chinese goddess of the Moon.
- Hence the name of China's latest probe, the Chang'e-4. Part of China's Lunar Exploration Program (CLEP), plans to land the probe and accompanying rover on the far side of the moon.
- Chang'e-4 will follow the Chang'e-3, a probe launched in 2013, which carried the Jade Rabbit rover to the lunar surface. Though currently immobile, Jade Rabbit still transmits data back to Earth, and Chang'e-4 would take on a different scientific role.
- Much of the Moon's far side southern hemisphere is covered by the South Pole-Aitken basin, one of the largest impact craters in the solar system.
- This crater on the far side could have completely reshaped cultural mythologies had it been on the nearside. The Aitken basin could have made the moon appear to be an ominous eye in the sky. An ancient, eternal Big Brother. A body to be feared rather than worshipped.

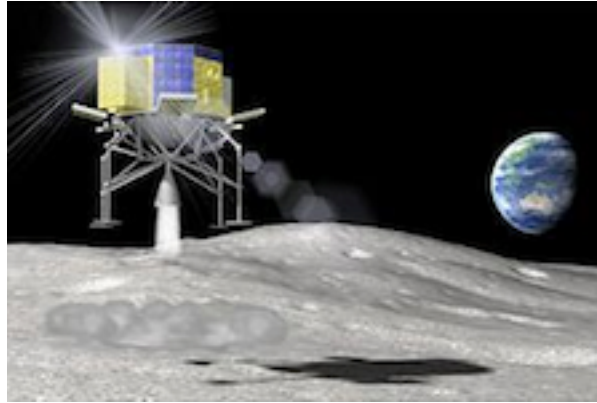
### It's not called the "dark side" for nothing.

- The same impact which formed the crater may have also partially excavated parts of the mantle.
- If those parts of the Moon's interior can be studied, it could offer one-of-a-kind insights into what the Moon is made of and where it came from.
- The basin would also be an ideal spot to place permanent radio telescopes. These could reach into the depths of space without interference from Earth's transmissions or atmosphere.
- A successful landing on the far side would also give the Chinese tremendous bragging rights. While the far side of the Moon has been observed by various probes, a landing has never been attempted, much less accomplished, largely because it's more technically difficult.
- Before Chang'e 4 is launched, Chang'e-5, in 2017 will return with lunar samples. The chronology discrepancy can be attributed to the fact that Chang'e-4 is technically the backup to Chang'e-3, and will keep that number identifier despite launching after Chang'e-5.
- Beijing has also planned a mission to Mars, sometime around 2020, to return to Earth with samples, which could be another Space Age first. ##

## Japan to land its first unmanned spacecraft on the Moon in 2018

[www.space-travel.com/reports/Japan\\_to\\_Land\\_First\\_Unmanned\\_Spacecraft\\_on\\_Moon\\_in\\_2018\\_999.html](http://www.space-travel.com/reports/Japan_to_Land_First_Unmanned_Spacecraft_on_Moon_in_2018_999.html)

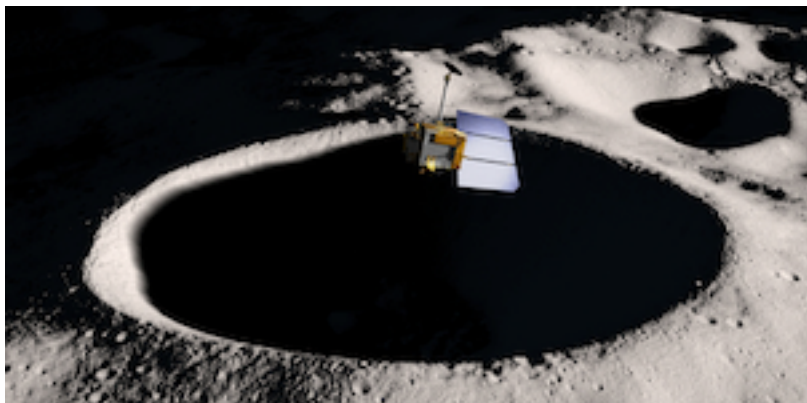
23 April, 2015 – Japan's Aerospace Exploration Agency (JAXA) is **expected to unveil its plan** planning to deliver its first lander on the surface of the Moon in three years, to Japan's space policy committee.



- A more detailed project estimated to cost from \$8 to \$12.5 billion to land the unmanned **SLIM space vehicle** is expected to be unveiled soon.
- SLIM will be launched by JAXA's **Epsilon-5 carrier rocket** and will be key to future Mars explorations.
- The new SLIM probe will demonstrate an ability to rapidly assess **surface topography** and **identify possible obstacles to landing**. ##

## NASA's Lunar Reconnaissance Orbiter swooping lowest ever over Moon

2 May, 2015 – [www.space.com/29466-nasa-lro-spacecraft-closest-moon-orbit.html](http://www.space.com/29466-nasa-lro-spacecraft-closest-moon-orbit.html)



A visualization of NASA's Lunar Reconnaissance Orbiter passing low over the Moon's surface near the lunar south pole at a height of just 20 km (12 mi)

- LRO has dipped closer to the Moon's surface than ever before, setting the stage for a new discoveries.
- On May 4, LRO performed two engine burns, changing its orbit to one that gets within 20 km (12 mi) of the Moon's south pole, (10 km, 7 mi lower than before) and 165 km (103 mi) of the north pole.
- Lowering LRO's orbit essentially **magnifies the sensitivity of LRO's six science instruments**, to learn more about how water and other compounds could be trapped at the Moon's poles.
- Two instruments aboard LRO should especially benefit from the orbit change — the Lunar Orbiter Laser Altimeter (LOLA), which builds a topographical map of the Moon's surface, and the Diviner Lunar Radiometer Experiment, which maps the Moon's temperature.
- Getting closer to the surface allows LOLA's lasers to return a stronger signal that can lead to more detailed measurements of the geography at the Moon's north and south poles.
- LRO's orbit change should also allow Diviner to record smaller features of the Moon with higher resolution data of lunar temperature changes from day to night.
- Enhanced data from Diviner may provide more evidence of ice and water on the Moon that could help NASA and other organizations better plan out future human missions to the Moon. ##

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## Russia to Land Probe on Moon's Polar Region in 2019

[www.space-travel.com/reports/Russia to Land Space Vessel on Moons Polar Region in 2019 999.html](http://www.space-travel.com/reports/Russia_to_Land_Space_Vessel_on_Moons_Polar_Region_in_2019_999.html)

25 June, 2015 – Russia's lunar research is undergoing "Earth trials" before landing on the Moon in 2019.

- The main construction documentation has been started
- The models for independent and complex trials have been prepared.
- Luna-25 is targeted for the Moon's south polar region instead of the equator.
- The research plans to explore internal structure of the Moon and the impact of the cosmic rays and electromagnetic radiation on the lunar surface, and to search for natural resources in the area. ##

## MOON – HUMAN EXPLORATION & SETTLEMENT 25 Jun

### Russia Invites China to Join in Creating Lunar Station

[www.space-travel.com/reports/Russia Invites China to Join in Creating Lunar Station 999.html](http://www.space-travel.com/reports/Russia_Invites_China_to_Join_in_Creating_Lunar_Station_999.html)

29 April, 2015 – Russia and China are currently in talks on inviting the latter to become one of the main partners in creating a lunar station.

- Both parties share "deep mutual understanding and mutual interests" in this area.
- Beijing is planning to boost its cooperation with Russia in a number of spheres, including space.
- Exploration of the Moon and Mars is a priority for the Russian space program.
- Russia plans to launch its national orbital station by 2023.
- The station is to serve as a base for Russia's lunar program. Spacecraft will be delivered first to the station, then proceeding to the Moon.
- Russia is expected to carry out a manned mission orbiting the Moon in 2025 and conduct a manned landing on the surface of the Moon in 2029.

### Schackleton Energy's Plan to use Lunar Ice to fuel the opening of the Moon

[www.shackletonenergy.com](http://www.shackletonenergy.com) – VIDEO

### Europe's Next Space Chief Wants a Moon Colony on the Lunar Far Side

[www.space.com/29285-moon-base-european-space-agency.html](http://www.space.com/29285-moon-base-european-space-agency.html)

1 May, 2015 – The incoming leader of the European Space Agency is keen on establishing an international base on the Moon as a next-step outpost beyond the International Space Station (ISS).

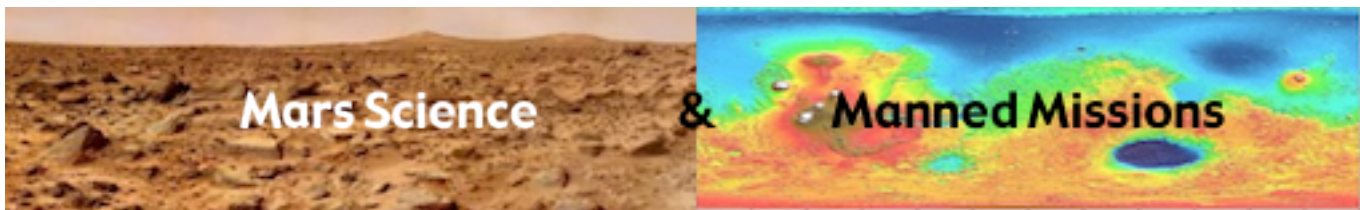
- Johann-Dietrich Wörner expressed his enthusiasm for a Moon colony at the Space Foundation's National Space Symposium, in Colorado Springs, CO April 13 to April 16.
- "It seems to be appropriate to propose a permanent moon station as the successor of ISS."
- The collaborating space agencies would contribute their respective competencies.
- The Moon station can be an important stepping stone for any further exploration in deep space
- A lunar outpost could help us learn how to use resources on-site instead of transporting them.
- The space community should rapidly discuss post-ISS proposals with the general public informed

#### The case for the Moon

- Wörner will become the next director general of the European Space Agency (ESA) on June 30.
- Currently, Wörner is chairman of the executive board of DLR, the German Aerospace Center. He advocated a lunar far-side base at the 31st National Space Symposium, both in a panel of space agency leaders and during a focused panel on space in Germany.
- Wörner also asserted that a **far-side outpost on the Moon** offers a number of "drivers," including cosmological research.
- The lunar farside is shielded from radiation-chatter broadcasts from Earth, allowing radio telescopes built there to survey the universe with very little background noise.
- The global space community should seek out joint activities that a single nation cannot realize. ##

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[The articles below have been summarized by the editor. For the full text, see the links cited.]

## MARS ANALOG EXERCISES

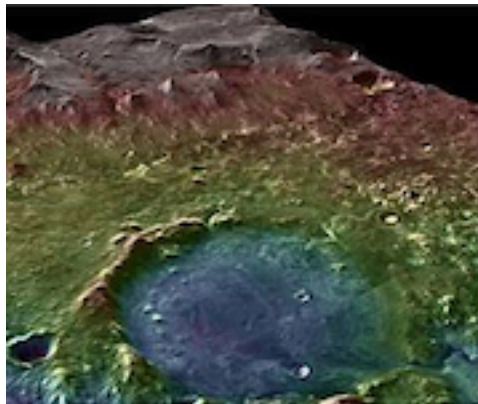
## MARS MISSIONS

### Ancient Martian lake system records 2 water-related events

[www.marsdaily.com/reports/Ancient\\_Martian\\_lake\\_system\\_records\\_2\\_water\\_related\\_events\\_999.html](http://www.marsdaily.com/reports/Ancient_Martian_lake_system_records_2_water_related_events_999.html)

26 March, 2015 – Researchers from Brown Univ. have completed a new analysis of an ancient Martian lake system in Jezero Crater, near the planet's equator.

- The study finds that the onslaught of water that filled the crater was one of at least two separate periods of water activity in the region surrounding Jezero.



A false-color topographic map (blue marks low elevations) shows the area around Mars's Jezero Crater, which was home to an ancient lake system. New research shows that the region around Jezero hosted at least two separate episodes of water

- This one really well-exposed location makes a strong case for at least two periods of water-related activity in Mars' history.
- The study is in press in the Journal of Geophysical Research: Planets.
- The ancient lake at Jezero crater was first identified in 2005 and two channels on the northern and western sides of the crater that appear to have supplied it with water, were identified..
- The water eventually overtopped the crater wall on the southern side, flowing out a 3rd large channel.
- It's not clear how long the system was active, but may have dried out c. 3.5 to 3.8 billion years ago.
- Each crater inlet channels has a delta-like deposit through which sediment was deposited in the lake. In 2008, it was shown that those fan deposits are full of clay minerals -- a sign of alteration by water.
- The question of how exactly those minerals formed, however, remained open.
- Did the minerals form in place in the lake, or elsewhere and get transported into the lake?
- To answer the question, high-resolution orbital images from NASA's CTX instrument were combined with data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) aboard NASA's Mars Reconnaissance Orbiter.
- Using those two sources, a detailed geological and mineralogical map of the entire Jezero Crater paleolake system could be produced
- The map showed that each of the fan deposits has its own distinct mineral signature that matches the signature of the watershed from which it was sourced, a good indication that the minerals formed in the watershed and were then transported into the lake.

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- The minerals' formation and transportation seem to have been separated by a fair amount of time.
- Mapping of the watershed showed a younger layer of rock that sits on top of the hydrated minerals
- The crater's inlet channels cut through that layer of younger rock, indicating that the channels must have flowed well after the mineral layer had formed.
- This implies that there were actually two periods of water-related activity
- The earlier episode formed the alteration minerals in the watershed,
- The surface water activity that transported the minerals into the lake sometime later.
- Those two events appear not to have been genetically related.
- That finding could shed light on the water story for early Mars.
- It's clear that Mars was once much wetter than it is now.
- It's not clear if Mars' climate was warm enough to sustain liquid water at the surface for long periods.
- If the early Martian climate was cold, chemical alteration on Mars may have been driven largely by water percolating in the warmer subsurface crust.
- That period of subsurface activity was followed some time later by pulses of water on the surface -- potentially sourced by either snowmelt or rainfall -- during transient periods of warm temperatures.
- That 2nd round of events was largely responsible for the mechanical erosion on the Martian surface.
- The events at Jezero seem to be consistent with that idea.
- Jezero crater records the history of two separate water events making it an itarget for future study.
- Jezero is high on scientists' list of possible landing sites for NASA's Mars 2020 rover.
- If life had emerged in either of the two water-related events, we may find signs of it at Jezero.
- River and lake deposits on Earth are some of the best preservers of biologic signatures.
- At Jezero, we're gathering all this material from a huge watershed and dumping into one place.
- If there was any biologic or organic material in the watershed, some of it may be found in this basin.
- Water in the lake from the 2nd event doesn't seem to have chemically altered the rock much at all.
- That helps confirm what previous researchers had suspected: that Jezero was filled with fairly fresh water with a nearly neutral pH -- making it a potentially habitable environment.
- NASA held a workshop last May to start the process of selecting sites for the 2020 rover. Goudge and his colleagues gave a presentation making the case for Jezero, and the scientists in attendance voted it as one of the top five landing site candidates. There are several more rounds of the selection process to go, and Goudge hopes Jezero will stay in contention. ##

## Curiosity Rover Finds Biologically Useful Nitrogen on Mars

[www.marsdaily.com/reports/Curiosity\\_Rover\\_Finds\\_Biologically\\_Useful\\_Nitrogen\\_on\\_Mars\\_999.html](http://www.marsdaily.com/reports/Curiosity_Rover_Finds_Biologically_Useful_Nitrogen_on_Mars_999.html)

6 March, 2015 – A team using the Sample Analysis at Mars (SAM) instrument suite aboard NASA's Curiosity rover has made the first detection of nitrogen on the surface of Mars, released during heating of Martian sediments.

- The Nitric oxide detected could be released from the breakdown of nitrates during heating.
- Nitrates are a class of molecules that contain nitrogen in a form that can be used by living organisms.
- This discovery adds to the evidence that ancient Mars was habitable for life.
- Nitrogen is essential for all known forms of life, used in the building blocks of larger molecules
  - DNA and RNA encode the genetic instructions for life,
  - Proteins build structures like hair and nails, and speed up or regulate chemical reactions.
- However, on Earth and Mars, atmospheric nitrogen is locked up as nitrogen gas (N<sub>2</sub>) – two atoms of nitrogen bound together so strongly that they do not react easily with other molecules.
- The nitrogen atoms have to be separated or "fixed" so they can participate in the chemical reactions needed for life.
- On Earth, certain organisms are capable of fixing atmospheric nitrogen, critical for metabolic activity.
- However, smaller amounts of nitrogen are also fixed by energetic events like lightning strikes.
- Nitrates (NO<sub>3</sub>) are a source of fixed nitrogen.
- A nitrate molecule can join with various other atoms and molecules: nitrates.

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- There is no evidence to suggest that fixed nitrogen molecules found by the team were created by life.
- The surface of Mars is inhospitable for known forms of life.
- Instead, these nitrates may be ancient, from non-biological processes like meteorite impacts and lightning in Mars' distant past.
- Features resembling dry riverbeds and discovery of minerals that form only in the presence of liquid water suggest that Mars was more hospitable in the remote past.
- The Curiosity team has found evidence that other ingredients needed for life, such as liquid water and organic matter, were present on Mars at the Curiosity site in Gale Crater billions of years ago.
- Finding a biochemically accessible form of nitrogen is more support for the ancient Martian environment at Gale Crater being habitable.
- They found evidence for nitrates in scooped samples of windblown sand and dust at the "Rocknest" site, and in samples from mudstone at the "John Klein" and "Cumberland" drill sites in Yellowknife Bay.
- As the Rocknest sample is a combination of dust blown in from distant regions and more locally sourced materials, the nitrates are likely to be widespread across Mars
- The results indicate up to 1,100 parts per million nitrates in the Martian soil from the drill sites.
- The mudstone at Yellowknife Bay may have formed from sediment deposited at the bottom of a lake.
- Previously the rover team described the evidence for an ancient, habitable environment there in the form of fresh water, key chemical elements required by life, such as carbon, and potential energy sources to drive metabolism in simple organisms.
- The samples were first heated to release molecules bound to the Martian soil, then portions of the gases released were diverted to the SAM instruments for analysis.
- Various nitrogen-bearing compounds were identified with two instruments:
  - ✓ a mass spectrometer uses electric fields to identify molecules by their signature masses
  - ✓ a gas chromatograph, separates molecules by the time they take to travel through a small glass capillary tube – some molecules interact with the tube sides more readily and travel more slowly.
- Also detected in all three sites was nitric oxide (NO).
- Since nitrate is a nitrogen atom bound to three oxygen atoms, the team thinks most of the NO likely came from nitrate which decomposed as the samples were heated for analysis.
- Certain compounds in the SAM instrument can also release nitrogen as samples are heated
- But the amount of NO found is more than twice what could be produced by SAM in the most extreme and unrealistic scenario.
- This leads the team to think that nitrates really are present on Mars, and the abundance estimates reported have been adjusted to reflect this potential additional source.
- "Scientists have long thought that nitrates would be produced on Mars from the energy released in meteorite impacts, and the amounts we found agree well with estimates from this process. ##

## Curiosity Sniffs Out History of Martian Atmosphere – Xenon

[www.nasa.gov/press/2015/march/curiosity-sniffs-out-history-of-martian-atmosphere/](http://www.nasa.gov/press/2015/march/curiosity-sniffs-out-history-of-martian-atmosphere/)  
<http://en.wikipedia.org/wiki/Xenon>

31 March, 2015 – NASA's Curiosity rover is using a new experiment to better understand the history of the Martian atmosphere by analyzing **Xenon**,

- This winter [in Mars Northern hemisphere], some rover team members were busy analyzing the Martian atmosphere for this heavy noble gas. With Curiosity's Sample Analysis at Mars..
- Since noble gases are chemically inert and do not react with other substances in the air or on the ground, they are excellent tracers of the history of the atmosphere.
- Xenon is present in the Martian atmosphere at a challengingly low quantity and can be directly measured only with on-site experiments such as SAM.
- Xenon is a fundamental measurement to make since it provides essential information to understand the early history of these planets and why they turned out so differently from Earth.
- A planetary atmosphere is made up of different gases, which are in turn made up of variants of the same chemical element called isotopes.
- When a planet loses its atmosphere, that process can affect the ratios of remaining isotopes.

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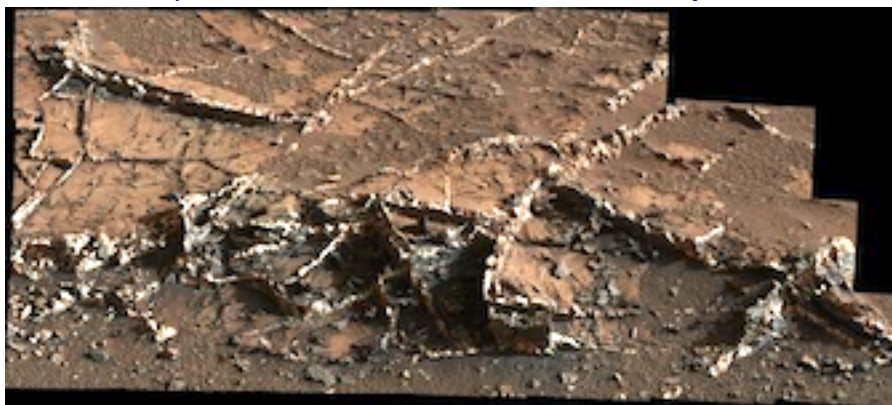


A Sample Analysis at NASA Goddard. This test is inside a chamber that, when closed, can model the pressure and temperature environment that SAM sees inside Curiosity on Mars.

- Xenon exists naturally in nine different isotopes, ranging in atomic mass from 124 (with 70 neutrons per atom) to 136 (with 82 neutrons per atom) This allows us to learn more about the process by which the layers of atmosphere were stripped off of Mars than using measurements of other gases.
- A process removing gas from the top of the atmosphere removes lighter isotopes more readily than heavier ones leaving a ratio higher in heavier isotopes than it was originally.
- The SAM measurement of \ ratios of the nine xenon isotopes traces a very early period in the history of Mars when a vigorous atmospheric escape process was pulling away even the heavy xenon gas.
- The lighter isotopes were escaping just a bit faster than the heavy isotopes.
- Those escapes affected the ratio of isotopes in the atmosphere left behind, and the ratios today are a signature retained in the atmosphere for billions of years.
- This signature was first inferred several decades ago from isotope measurements on small amounts of Martian atmospheric gas trapped in rocks from Mars that made their way to Earth as meteorites.
- SAM previously measured the ratio of two isotopes of a different noble gas, argon. The results pointed to continuous loss over time of much of the original atmosphere of Mars.
- The xenon experiment required months of careful testing at NASA's Goddard in Greenbelt, Maryland, using a close copy of the SAM instrument enclosed in a chamber that simulates the Mars environment.
- This testing was led by Goddard's Charles Malespin, who developed and optimized the sequence of instructions for SAM to carry out on Mars. ##

## Mars Rover Curiosity Spots 'Ice Cream Sandwich' Rocks (Photos)

2 April, 2015 - [www.space.com/29001-mars-rover-curiosity-ice-cream-rocks.html](http://www.space.com/29001-mars-rover-curiosity-ice-cream-rocks.html)

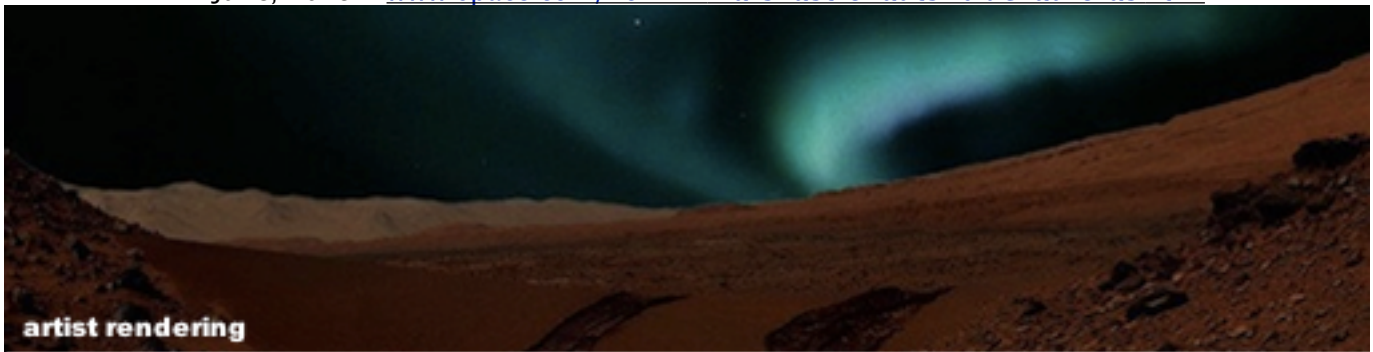


This photo, taken by NASA's Mars rover Curiosity on March 18, 2015, shows a network of two-tone mineral veins at an area called "Garden City" in the foothills of Mount Sharp.



## Pioneers on Mars Could See Blue Auroras

24 June, 2015 - [www.space.com/29744-mars-astronauts-blue-auroras.html](http://www.space.com/29744-mars-astronauts-blue-auroras.html)



Astronauts visiting Mars will be awed by dazzling auroral displays in Mars' southern hemisphere. While previous research had confirmed the presence of beautiful "southern lights" on Mars, the new study predicts for the first time that the auroras of the Red Planet may be visible to the human eye.

- An astronaut looking up after intense solar eruptions, could see the phenomena with the naked eye.
- Our northern or southern lights occur when charged particles from the sun are caught by Earth's magnetic field which excite the atoms and molecules of the atmosphere, and produce light emission.
- The well-known greens and reds stem from the excitation of oxygen, while blue and purple colors result from ionized molecular nitrogen.
- Although Mars no longer has a global magnetic field, small fields still appear sporadically across the planet today, primarily in the southern hemisphere.
- Whereas Earth's global magnetic field funnels charged particles toward the north and south poles, the more sporadic fields of Mars make the location of the auroras more variable.
- Previous observations by the Europe's Mars Express spacecraft and NASA's MAVEN mission confirmed the presence of auroras on Mars, but could not determine if they would be visible to humans.
- For the new study, researchers utilized a Planeterella — a sphere inside which magnetic fields and charged particles produce simulated auroral displays. The study team used one in France.
- Scientists loaded up this Planeterella with carbon dioxide, the dominant component of the thin Martian atmosphere. An electrical discharge was created in the region similar to the planet's upper atmosphere, creating a blue glow that followed the magnetic field structure.
- The results should help us better understand the physics, mass and evolution of Mars' atmosphere. ##

## NASA's 'Flying Saucer' Takes a Spin Ahead of June Flight Test

[www.space.com/28985-nasa-flying-saucer-mars-landing-test.html](http://www.space.com/28985-nasa-flying-saucer-mars-landing-test.html)

[www.space.com/25492-nasa-flying-saucer-mars-landings-photos.html](http://www.space.com/25492-nasa-flying-saucer-mars-landings-photos.html)



NASA's Low-Density Supersonic Decelerator (LDSD) test vehicle undergoes a spin test at the agency's Jet Propulsion Laboratory in Pasadena, California on March 31, 2015.

- NASA put some new Mars-landing tech through its paces to prepare for a June flight test from Hawaii.
- Engineers subjected the saucer-shaped Low-Density Supersonic Decelerator (LDSO) test vehicle, part of a project designed to help get heavy payloads down safely on Mars, to a "spin table" test March 31st at the Jet Propulsion Laboratory (JPL) in Pasadena, California.
- The main goal was to look for any wobbles caused by an imperfect distribution of mass throughout the 4.6 m (15-ft) wide, 3,175 kg (7,000-lbs) LDSO vehicle.
- Any wobbles can be corrected by inserting small masses at appropriate points around the craft's rim, not unlike spinning your automobile tire, and putting weights on it to make sure it spins perfectly.
- The LDSO project is developing and testing saucerlike devices called Supersonic Inflatable Aerodynamic Decelerators (SIADs) and a 31 m (100-ft)-wide supersonic parachute — the biggest ever flown.
- For comparison, NASA's [Mars rover Curiosity](#) mission used a 15.5 m (51ft) wide parachute.)
- The SIADs are designed to fit around the rim of an entry vehicle.
- They will inflate as the craft screams through the atmosphere of its target planet, increasing surface area and drag, and thus slowing down the vehicle.

**Editor:** this idea was illustre sated in the science fiction film, *Space Oddessy II* ---- and called a "ballute"

- NASA officials hope such technology can increase the size of the payloads it can put down on Mars.
- The "sky crane" system that landed Curiosity August 2012 can handle about 1 metric ton — far short of the 10–20 metric tons (about 11–22 tons) that will be required for manned exploration of Mars.
- The LDSO vehicle incorporates a 6 m (20-ft)-wide SIAD as well as the big chute
- It is in final preparations for shipment to Hawaii to undergo the program's 2nd-ever flight test from the U.S. Navy's Pacific Missile Range Facility on the island of Kauai June 2–12, weather permitting.
- During the first LDSO flight test last June from the same facility, a huge balloon carried a test vehicle up to an altitude of 37 km (23 mi).
- The balloon then dropped the craft, the onboard rocket motor kicked on, and it boosted to Mach 4 and an altitude of 34 miles (55 km).
- The air that high is a good analog for Mars' atmosphere, just 1% as thick as that of Earth at sea level.
- But the parachute tore almost immediately upon deployment.
- The team has changed the chute's design for the upcoming flight test, strengthening some elements and modifying its shape.
- Will it be strong enough? Another balloon-aided ftest will likely launch from Kauai in summer 2016. ##

## Supersonic decelerator gets a lift to prepare for launch

[www.marsdaily.com/reports/Supersonic-Decelerator-Gets-a-Lift-to-Prepare-for-Launch-999.html](http://www.marsdaily.com/reports/Supersonic-Decelerator-Gets-a-Lift-to-Prepare-for-Launch-999.html)

27 May, 2015 – NASA teams are continuing preparations for the **Low-Density Supersonic Decelerator** (LDSO) test off the coast of Hawaii June 2–12. This week the team completed a number of key pre-test procedures, including a successful mate between the test vehicle and balloon support systems.



NASA's Low Density Supersonic Decelerator project is designed to investigate and test breakthrough technologies for landing future robotic and human Mars missions, and safely returning large payloads.

**Larger image:** <http://blogs.nasa.gov/ldsd/wp-content/uploads/sites/248/2015/05/Unknown.jpeg>

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

### What this LDSD technology is – and why it's important to future missions to Mars

- It's about mass, speed and safety for ambitious robotic and human missions to Mars, which will require **larger, more complex spacecraft** than we've ever flown before.
- Sizeable payloads are needed to accommodate long stays on the Martian surface
- That means finding new ways to slow down when our spacecraft reach their destinations, effectively countering those faster flights and payloads of greater mass.
- Current deceleration technologies date back to NASA's two Viking landers on Mars in 1976. The basic Viking parachute design has been used ever since
- The 2012 delivery of the Curiosity rover to Mars used a whole new system, not to slow down, but to lower the rover to the ground without stirring up the surface

### NASA's LDSD project is conducting full-scale flight tests of two breakthrough technologies:

- A supersonic inflatable aerodynamic decelerator, or SIAD
- An innovative new parachute.
- These devices could deliver double the current amount of payload – 1.5 metric tons – to Mars surface.
- They also will greatly increase the accessible surface area that we can explore
- This will **improve landing accuracy** from a margin of 10.5 km (c. 6.5 mi) to a little over 1.6 km (1 m).
- All these factors will dramatically increase the success of future missions on Mars. ##

## NASA's LDSD Project Completes Second Experimental Test Flight

[www.nasa.gov/press-release/nasas-ldsd-project-completes-second-experimental-test-flight](http://www.nasa.gov/press-release/nasas-ldsd-project-completes-second-experimental-test-flight)

9 June, 2015 – Engineers are poring over the data following the 2nd experimental landing technology test of NASA's Low-Density Supersonic Decelerator (LDSD) project. The saucer-shaped LDSD craft splashed down June 8 in the Pacific Ocean off the west coast of the Hawaiian island of Kauai.

- During this flight, the team tested two decelerator technologies that could enable larger payloads to land safely on the surface of Mars, and allow access to higher-altitude (thinner air) sites.
- The technologies tested on LDSD are giving us data and insight into the capabilities we'll need to land more mass than we currently can on Mars, which will enable more capable robotic missions, as well as human precursor missions to the Red Planet.
- This 100-foot-wide parachute is the largest supersonic parachute ever flown. It has more than double the area of the parachute used for the Mars Science Laboratory (Curiosity) mission.
- The chute began to generate large amounts of drag and a tear appeared in the canopy at about the time it was fully inflated.
- Monday's flight test was the 2nd for the project. During the first flight on June 28, 2014, the supersonic parachute did not inflate as designed. With the data from last year's test, the LDSD team developed a new formula for this year's chute, making it stronger and more curved into its top to help it survive the initial shock of supersonic wind.
- NASA expects to make high-resolution imagery and comprehensive data from the test available to the public in about two weeks. ##

## Ancient Mars May Have Had Slow-Moving Monster Waves

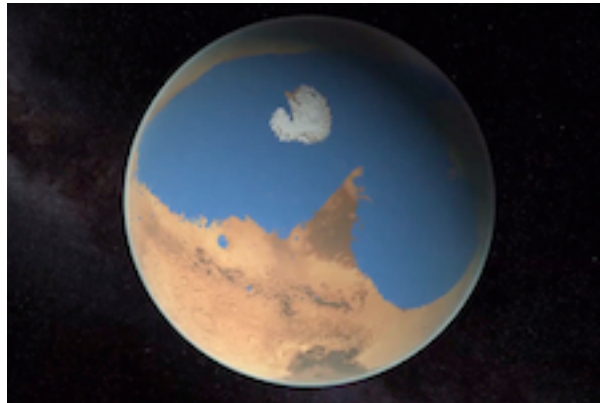
1 April, 2015 – [www.space.com/28983-ancient-mars-oceans-big-waves.html](http://www.space.com/28983-ancient-mars-oceans-big-waves.html)

[www.space.com/28745-ocean-covered-20-percent-of-mars-new-research-suggests-video.html](http://www.space.com/28745-ocean-covered-20-percent-of-mars-new-research-suggests-video.html)

Surfing may have been a more epic undertaking on ancient Mars than it is on modern-day Earth because of the possible existence of giant, slow-moving waves on the Red Planet.

- These big waves might have carved shorelines into Mars long ago.
- If so, studying these shorelines could shed light on the ancient Martian climate, such as whether or not it had seas long enough for life to potentially develop on the Red Planet.

- Although Mars is now too cold and dry for liquid water to last on its surface very long, orbital images from the Mariner 9 mission in the early 1970s and many other findings since then suggest that as much as 20% of the planet was once covered in rivers and seas.
- The existence of ancient Martian oceans would explain why the northern lowlands of Mars resemble the abyssal plains of Earth's ocean floors.



Maps of water in the Martian atmosphere suggest Mars once had an ocean that covered 20% of its surface. Most of that water was subsequently lost to space.

- Researchers are still debating the existence and extent of ancient seas on the Red Planet. This is due in part to the fact that much remains unclear about what the ancient Martian environment was like.
- Because of that uncertainty, many questions remain about whether or not the Red Planet's climate was capable of sustaining liquid water on its surface for long periods of time. [Martian oceans](#)
- Unanswered is the question whether or not waves on Martian oceans could have cut shorelines.
- If these past shorelines could strengthen the case for ancient seas on Mars and shed light on what the ancient Martian environment was like.
- Identification of a wave-cut shoreline on [Mars](#) could tell us the minimum wind strength at the time.
- Since there is a link between wind strength and atmospheric pressure, we could deduce the atmospheric pressure on early Mars and give us a better constraining the ancient history of Mars' climate.
- The strength of waves depends greatly on the strength of the winds blowing on water, which in turn depends in part on the thickness of the atmosphere.
- The atmosphere of Mars is currently very thin. While atmospheric pressure of Earth is slightly more than 1,000 millibars at sea level, the pressure of Mars is now less than 0.5 % of that, at 6 millibars.
- It is still unclear how thick Mars' atmosphere might have been in the past.
- Computer simulation estimates between the current 6 millibars up to 2,000 millibars have been made.
- They modeled wind speeds similar to ones currently seen on Mars, from 18 to 72 km/h (11–44 mph).
- Mars' gravitational field is only 38 % as strong as Earth's, making it easier for waves to rise there.
- Even at very low atmospheric pressure like on Mars now, you could generate waves in a liquid surface.
- Assuming that Mars was once warm enough to have open seas not packed with ice, with an atmospheric pressure of 50 millibars, winds of 32.4 km/h (20 mph) or more for waves would be needed.
- If the atmospheric pressure was 200 millibars, winds of only about 14.4 km/h (9 mph) would do.
- If atmospheric pressure was as high as Earth's at 1,000 millibars, winds of just 5 km/h (3 mph) would have been necessary.
- Martian waves might have shapes similar to Earth waves, but would move significantly slower, as water waves move forward due to the force of gravity, smaller on Mars, about half as fast as on Earth.
- Even if no wave-cut shorelines are ever found on Mars, that does not mean Mars never had waves.
- A wave-cut shoreline built up 3.5 billion years ago might not survive to the present day.
- The lack of a shoreline doesn't is not definitive for purely intellectual reasons.
- What kind of shorelines might result from ancient Martian oceans packed with ice?
- On Earth, when the wind blows on ice sheets, it pushes them onto shore, making big ramparts. Perhaps these ramparts or their remnants exist on [Mars](#), and if so, can we then use them to constrain the pressures and wind speeds that must have occurred? ##



## Warm or cold? Mars' history takes a watery new twist

[www.marsdaily.com/reports/Warm\\_or\\_cold\\_Mars\\_history\\_takes\\_a\\_watery\\_new\\_twist\\_999.html](http://www.marsdaily.com/reports/Warm_or_cold_Mars_history_takes_a_watery_new_twist_999.html)

2 April, 2015 – A new, six-year analysis of water on Mars suggests that it has **lost the equivalent of an ocean's worth of water over the past four billion years.**

- However, whether Mars was ever warm enough to have hosted such an ocean has sparked debate.
- Research, conducted using the European Southern Observatory's Very Large Telescope (VLT) in Chile, and supported by the WM Keck Observatory and NASA's Infrared Telescope Facility, both in Hawaii, has revealed how much water has escaped from Mars' atmosphere throughout its history.
- The results suggest that **the lost water could have once filled an ocean in Mars' northern lowlands to a depth of up to 1.6 km (1.0 m), covering 19 % of Mars' surface.**
- This implies that a substantial amount of water was available during the first billion years on Mars
- This raises the possibility that ancient Mars was habitable.

**The team used water molecule chemistry to trace the history of Mars' water back through time.**

- "Normal" water is H<sub>2</sub>O, but there is also "heavy water" with two neutrons, D<sub>2</sub>O and "semi heavy water" with a proton and a neutron in its nucleus: HD<sub>2</sub>O.
- Regular water can be stripped from Mars' atmosphere and lost to space much more easily than heavy or semi-heavy water.
- Over a long time, "normal" H<sub>2</sub>O will escape preferentially relative to the heavier forms
- Over billions of years, this preferential water loss has left Mars enriched in semi-heavy water compared to regular water by a factor of seven times greater than the ratio in Earth's water.
- Extrapolating backwards from the current ratio of hydrogen to deuterium, and incorporating factors such as collisions between water molecules and the predominant molecule in Mars' atmosphere, carbon dioxide, the team were able to calculate how much water Mars has lost.
- Mars still has water of course, locked up in its polar caps and underground.
- If you could take all the water that exists today on Mars, and put it on the surface in liquid form, it would form an ocean 21 meters deep (69 ft) still implying a relatively dry planet
- However, Mars has lost so much water – more than all the water in Earth's Arctic Ocean – that in the past it could potentially have created an ocean 137 m (449 ft) deep but probably frozen – ice not water.
- In comparison, Earth has enough water for a global ocean several kilometers deep.
- Their results are entirely consistent with a predominantly cold, icy scenario for early Mars
- If this analysis is correct, then what at first may have appeared to be a boon for theories that Mars was once warm and wet for sustained periods, may be nothing of the sort.
- Although we see evidence all over Mars that water once flowed freely, cutting river channels and gullies, spreading onto flood plains and altering the chemistry of the minerals near the surface, such evidence could have been created by liquid water acting over relatively short timescales.
- **If Mars really had a northern ocean, the planet's climate would need to have been warm for at least its first billion years.**
- Mineralogical evidence, such as carbonates or evaporites, typical of evidence for Earth's large ocean basins, has not been found in Mars' north, but some optimistic researchers are still looking.
- It is difficult to assess the temperature of ancient Mars, and for how long water might have been in liquid form. But the results do indicate that a substantial amount of water was available in the past.

**Crucial questions remain.**

- Part of the study was to determine patterns in seasonal microclimates on Mars, and whether there are any other sources of water that have passed into the atmosphere besides that now in Mars' ice caps.
- We still don't know how the molecules are escaping. NASA's MAVEN (Mars Atmosphere and Volatile Evolution) spacecraft, is in Mars orbit to investigate the history of Mars' atmosphere, and could peel away new layers in the mystery of Mars' water, giving us a much better idea of how and when the molecules escaped from Mars.
- The new results have constrained our ideas about how much water may have been present on the Red Planet's surface long ago, but they provide no concrete information about habitable conditions.
- The hope is that MAVEN will give us the conclusive history of water on Mars. ##

## On Mars, Liquid Water Appears at Night, Study Suggests

13 April, 2015 – <http://www.space.com/29072-mars-liquid-water-at-night.html>

The Curiosity rover has found **evidence that when temperatures drop on cold winter nights, trace amounts of water from the atmosphere can turn to frost, which can then be absorbed into the upper layers of the Martian soil and liquefied.**

- Liquid water evaporates into the atmosphere after sunrise, when temperatures start to go up again.
- Turning water from a solid (frost) to a liquid requires the **presence of a particular type of salt** that could melt the frost, even in very cold temperatures (why we put down on icy sidewalks and roads during winter).
- But the small amounts of liquid salt water in the soil would not be enough to support microbial life.
- The extreme temperatures would also make the environment too extreme.

### On the move

- Dry as a bone — one way to describe the Martian landscape today.

Although the planet once hosted flowing rivers and massive lakes (and is still home to water ice at its poles), scientists have found that some water could be extracted from the Martian soil).

- Apparently there is more going on underneath this desert than meets the eye.
- Digging into the soil, instruments on board Curiosity found a chemical called calcium perchlorate, a type of salt which absorbs frost from the soil surface, melts it, and creates a thin layer of salty brine.
- The liquefied water can then sink even lower in the Martian soil, mixing with other salts. The addition of liquid water allows them to move through the soil and relocate.

### Curiosity has not found direct evidence of these salty brine layers.

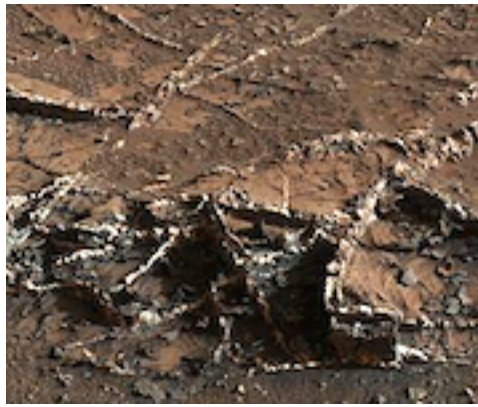
- The researchers combined analysis of the Martian soil, as well as the atmosphere just above the soil (humidity and temperature). The state of the perchlorates suggests an exchange of water between the soil and the atmosphere.
- Gale Crater lies close to the equator, Mars' hottest and driest region.
- The research suggests that these layers of brine may be even more abundant where there is higher humidity and lower temperatures.
- Curiosity has already found signs that rivers once flowed into a lake that stood where the arid Gale Crater now lies (as much of a fifth of the planet may have been covered in water at one point, making Mars potentially habitable).
- These rivers left behind sediment deposits that contained perchlorates and other salts.
- Very fine-grained sediments, slowly falling down through the water, were deposited right at the very bottom of the crater's lake.
- The sediment plates on the bottom are level, indicating that the entire Gale Crater may have been a large lake.
- The finding does not indicate that life can currently be found beneath the Martian surface.
- It does demonstrate that liquid water may be hidden in an otherwise parched landscape. ##

## Curiosity Eyes Prominent Mineral Veins on Mars

[www.marsdaily.com/reports/Curiosity\\_Eyes\\_Prominent\\_Mineral\\_Veins\\_on\\_Mars\\_999.html](http://www.marsdaily.com/reports/Curiosity_Eyes_Prominent_Mineral_Veins_on_Mars_999.html)

2 April, 2015 – Two-tone mineral veins at a site NASA's Curiosity rover reached by climbing a layered Martian mountain offer clues about multiple episodes of fluid movement that occurred later than the wet environmental conditions that formed lake-bed deposits the rover found at the mountain's base.

- In the past seven months, Curiosity analyzed rock samples drilled from 3 targets lower on the mountain.
- It found a different mineral composition at each, including a silica mineral named cristobalite in the most recent sample.
- These differences, together with the prominent veins a little farther uphill, illustrate how the layers of Mount Sharp provide a record of different stages in the evolution of the area's ancient environment.
- The two-tone veins at the site called "Garden City" appear as a network of ridges left standing above the now eroded-away bedrock in which they formed.



This March 18, 2015, view from the Mast Camera on the Curiosity Mars rover shows a network of 2-tone mineral veins at an area called "Garden City" on lower Mount Sharp.

A larger image. [www.jpl.nasa.gov/spaceimages/details.php?id=pia19161](http://www.jpl.nasa.gov/spaceimages/details.php?id=pia19161)

- Individual ridges range up to about 6 cm (2.5 in) high and half that width, both bright & dark material.
- "Some of them look like ice-cream sandwiches: dark on both edges and white in the middle.
- These materials indicate secondary fluids transported through the region after the host rock formed.
- Such veins form where fluids move through cracked rock and deposit minerals in the fractures, often affecting the chemistry of the rock surrounding the fractures.
- Curiosity has found bright veins composed of calcium sulfate at several previous locations.
- The dark material preserved there presents an opportunity to learn more.
- At least two secondary fluids have left evidence that may help to understand the chemistry of the different fluids that were here and the sequence of events and how later fluids affected the host rock.
- Some of the sequence is clear: Mud that formed lake-bed mudstones examined near Curiosity's 2012 landing site and on Mount Sharp must have dried and hardened before the fractures formed.
- Dark material that lines the fracture walls reflects an episode of fluid flow earlier than the white, calcium-sulfate-rich veins do, although both flows occurred after the cracks formed.
- Garden City is about 12 m (39 ft) higher than the bottom edge of the "Pahrump Hills" outcrop of the bedrock forming the basal layer of Mount Sharp, at the center of Mars' Gale Crater.
- The Curiosity mission spent about six months examining the first 10 m (33 ft) of elevation at Pahrump Hills, climbing from the lower edge to higher sections three times to vertically profile the rock structures and chemistry, and to select the best targets for drilling.
- We investigated Pahrump Hills the way a field geologist would, looking over the whole outcrop first to choose the best samples to collect. Analysis is still preliminary, but the three drilled samples from Pahrump Hills have clear differences in mineral ingredients.
- "Confidence Hills," had the most clay minerals and hematite, which form under wet conditions.
- "Mojave," had the most jarosite, an oxidized mineral containing iron and sulfur in acidic conditions.
- The third is "Telegraph Peak." Examination of Garden City did not include a drill sample and has almost no evidence of clay minerals, the hematite is nearly gone and jarosite abundance is down but c. 10 % or more of cristobalite, a mineral form of silica.
- The sample also contains a small amount of quartz, another form of silica.
- Among the possibilities are:
  - some process removed other ingredients, leaving an enrichment of silica behind
  - dissolved silica was delivered by fluid transport
  - the cristobalite formed elsewhere and was deposited with the original sediment.
- If Mars ever hosted microbes, and the changes from those environments to drier conditions that have prevailed on Mars for more than three billion years.
- After investigations in the Telegraph Peak area, Curiosity will pass through a valley called "Artist's Drive" to reach higher layers.
- Engineers are developing guidelines for best use of the rover's drill, after finding a transient short circuit while using the tool's percussion action to shake rock powder into a sample-processing device.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miw](http://www.nss.org/tothestars/miw) cepts

## Curiosity Sniffs Out History of Martian Atmosphere

[www.marsdaily.com/reports/Curiosity\\_Sniffs\\_Out\\_History\\_of\\_Martian\\_Atmosphere\\_999.html](http://www.marsdaily.com/reports/Curiosity_Sniffs_Out_History_of_Martian_Atmosphere_999.html)

2 April, 2015 – NASA's Curiosity rover is using a new experiment to better understand the history of the Martian atmosphere by analyzing xenon.

- Some rover team members have been analyzing Mars' atmosphere for xenon, a heavy noble gas.
- Curiosity's Sample Analysis at Mars (SAM) experiment analyzed xenon in Mars' atmosphere.
- Since noble gases are chemically inert and do not react with other substances in the air or on the ground, they are excellent tracers of the history of the atmosphere.
- Xenon is present in the Mars' atmosphere at a very low quantity and can be directly measured only with on-site experiments such as SAM.
- Xenon is useful to measure on a planet such as Mars or Venus, since it provides essential information to understand the early history of these planets and why they turned out so differently from Earth.
- A planetary atmosphere is made up of different gases, which are in turn made up of varying isotopes of each. When a planet loses its atmosphere, that process can affect the ratios of remaining isotopes.



A Sample Analysis at Mars (SAM) team member at NASA Goddard prepares the SAM testbed for an experiment. This test copy of the SAM suite of instruments is inside a chamber that, closed, models the pressure and temperature environment that SAM sees inside Curiosity on Mars

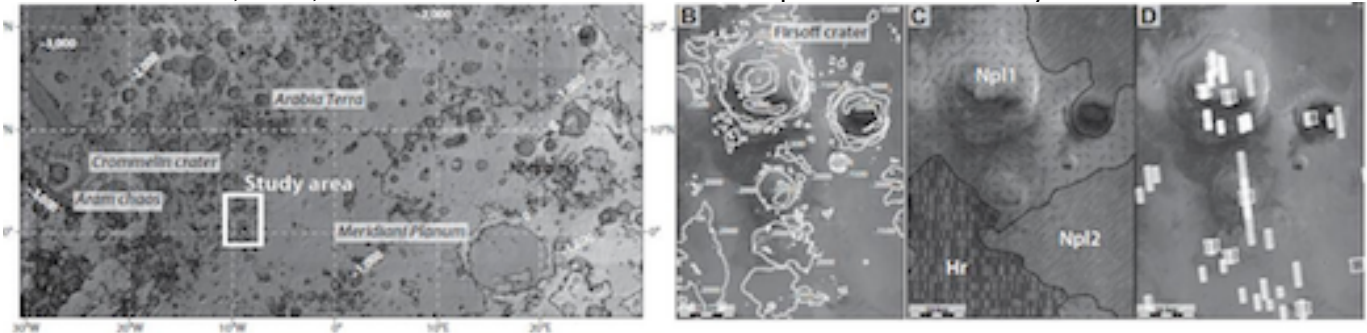
- Measuring xenon tells us more about the history of the loss of Mars' atmosphere.
- Xenon exists naturally in nine different isotopes, ranging in atomic mass from 124 (70 neutrons/atom) to 136 (82 neutrons/atom) – allowing us to learn more about the process by which the layers of atmosphere were stripped off of Mars than by using measurements of other gases.
- A process removing gas from the top of the atmosphere removes lighter isotopes more readily than heavier ones, leaving a ratio higher in heavier isotopes than it was originally.
- SAM measurements of the ratios of the nine xenon isotopes traces a very early period in the history of Mars when a vigorous atmospheric escape process was pulling away even the heavy xenon gas.
- The lighter isotopes were escaping just a bit faster than the heavy isotopes.
- Those escapes affected the ratio of isotopes in the atmosphere left behind, and **the ratios today are a signature retained in the atmosphere for billions of years.**
- This signature was first inferred several decades ago from isotope measurements on small amounts of Mars' atmospheric gas trapped in rocks from Mars that made their way to Earth as meteorites.
- There is a remarkably close match of the in-situ data to that from bits of atmosphere captured in some of the Martian meteorites.
- SAM's previous measurements of the ratio of two isotopes of a different noble gas, argon, pointed to a continuous loss over time of much of the original atmosphere of Mars.
- The xenon experiment required months of careful testing at NASA's Goddard Space Flight Center, using a close copy of the SAM instrument enclosed in a chamber that simulates the Mars environment.
- NASA's Mars Science Laboratory Project is using Curiosity to determine if life was possible on Mars and study major changes in Martian environmental conditions. ##



## More evidence for groundwater on Mars

7 April, 2015 – [www.marsdaily.com/reports/More\\_evidence\\_for\\_groundwater\\_on\\_Mars\\_999.html](http://www.marsdaily.com/reports/More_evidence_for_groundwater_on_Mars_999.html)  
[www.marsdaily.com/reports/Warm\\_or\\_cold\\_Mars\\_history\\_takes\\_a\\_watery\\_new\\_twist\\_999.html](http://www.marsdaily.com/reports/Warm_or_cold_Mars_history_takes_a_watery_new_twist_999.html)

Monica Pondrelli and colleagues investigated the Equatorial Layered Deposits (ELDs) of Arabia Terra in Firsoff crater area, Mars, to understand their formation and potential habitability.



For a larger image go here >> <http://www.eurekalert.org/multimedia/pub/89060.php>

- (A) Location map of the study area on MOLA-based shaded relief map. Topographic contours (in black, 1000 m spacing) are indicated.
- (B) A High Resolution Stereo Camera (HRSC) mosaic of the mapped area. Topographic contours (in white, 500 m apart) are indicated.
- (C) Excerpt of the geological map by Scott and Tanaka (1986) on an HRSC mosaic. Geologic units: Npl1--Noachian cratered unit of the plateau sequence; Npl2--Noachian subdued crater unit of the plateau sequence; Hr--Hesperian ridged plains material. (D) Footprints of High Resolution Imaging Science Experiment (HiRISE) coverage on an HRSC mosaic. The white filling indicates stereo pairs. The area is fully covered by Context Camera (CTX) imagery. Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) scenes used in this study are recognizable by the hourglass shape. Image courtesy Pondrelli et al. and GSA Bulletin.
- On the plateau, ELDs consist of rare mounds, flat-lying deposits, and cross-bedded dune fields.
  - Pondrelli and colleagues interpret the mounds as smaller spring deposits, the flat-lying deposits as playa, and the cross-bedded dune fields as aeolian. Groundwater fluctuations appear to be the major factor controlling ELD deposition.
  - The ELDs inside the craters would likely have originated by fluid upwelling through the fissure ridges and the mounds, and that lead to evaporite precipitation.
  - The presence of spring and playa deposits points to the possible presence of a hydrological cycle, driving groundwater upwelling on Mars at surface temperatures above freezing.
  - Conditions in a similar Earth environment would have been conducive for microbial colonization.
  - As a basis for this research, the team produced a detailed geological map of the Firsoff crater area which includes crater count dating, a survey of the stratigraphic relations, and analysis of the depositional geometries and compositional constraints.
  - This ELD unit consists of sulfates and shows other characteristics typical of evaporites such as polygonal pattern and indications of dissolution.
  - Equatorial layered deposits in Arabia Terra, Mars: Facies and process variability. ##

## Mars' dust-covered glacial belts may contain tons of water

[www.marsdaily.com/reports/Mars\\_dust-covered\\_glacial\\_belts\\_may\\_contain\\_tons\\_of\\_water\\_999.html](http://www.marsdaily.com/reports/Mars_dust-covered_glacial_belts_may_contain_tons_of_water_999.html)

9 April, 2015 – New research shows Mars' buried glaciers contain enough ice to cover the entire planet with a coat three feet thick.

- The evidence also proves the dust-covered glacial belts contain frozen water, not carbon dioxide.
- Previous satellite images have suggested the presence of hefty glacial bands spanning the planet's northern and southern hemispheres just beneath the Martian surface.
- But until now, researchers had not been able to confirm the glacial chemical makeup.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- New radar observations offer some clarity, by studying the movement of frozen formations over time.
- By comparing glacier behavior with hydraulic models, the presence of H<sub>2</sub>O. Has been confirmed.
- Radar measurements spanning ten years back in time tell how thick the ice is and how it behaves.
 

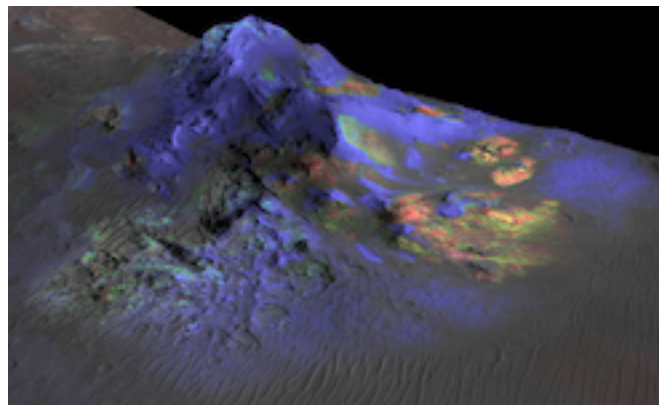
"A glacier is after all a big chunk of ice and it flows and gets a form that tells us something about how soft it is. We then compared this with how glaciers on Earth behave and from that we have been able to make models for the ice flow.'
- The team used radar observations to calculate the total mass of the thousands of glacial formations observed within the frozen belts.
- By studying the flow of the formations, scientists were able to make a more accurate estimation of the glaciers' volumes, concluding that the ice in the glaciers is equivalent to over 150 billion cubic meters of ice -- enough to cover the entire surface of Mars with 1.1 meters of ice," sn" important part of Mars' water reservoir."
- The layer of Martian dust covering the glacial belts has protected the frozen ice, preventing its evaporation in the planet's thin atmosphere. ##

## Mars Reconnaissance Orbiter Detects Impact Glass on Surface of Mars

[www.nasa.gov/press-release/nasa-spacecraft-detects-impact-glass-on-surface-of-mars](http://www.nasa.gov/press-release/nasa-spacecraft-detects-impact-glass-on-surface-of-mars)

8 June, 2015 – NASA's Mars Reconnaissance Orbiter (MRO) has detected deposits of glass within impact craters on Mars. Though formed in the searing heat of a violent impact, such deposits might provide a delicate window into the possibility of past life on the Red Planet.

- During the past few years, research has shown evidence that past life has been preserved in impact glass here on Earth, formed by an impact that occurred millions of years ago in Argentina.
- This finding suggests that similar processes might preserve signs of life on Mars, if they were present at the time of an impact.
- That finding showed that glasses are potentially important for preserving biosignatures
- Large glass deposits are present in several ancient, yet well-preserved, craters on Mars. Picking out the glassy deposits is no easy task. To identify minerals and rock types remotely, scientists measure the spectra of light reflected off the planet's surface. But impact glass doesn't have a particularly strong spectral signal.



Researchers have found deposits of impact glass (in green) preserved in Martian craters, including Alga Crater, shown here. The detection is based on data from the instrument Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on NASA's Mars Reconnaissance Orbiter.

- "Glasses tend to be spectrally bland or weakly expressive, so glass signatures tend to be overwhelmed by the chunks of rock mixed in with it, but a way to tease that signal out has been found.
- In a laboratory, powders with a similar composition of Martian rocks, were mixed together and fired in an oven to form glass. Then the spectral signal from that glass was measured.
- With the signal from the lab glass, an algorithm was used to pick out similar signals in data from MRO's Compact Reconnaissance Imaging Spectrometer for Mars (CRISM).
- The technique pinpointed **deposits in several Martian crater central peaks.**

- The fact the deposits were found on central peaks is a good indicator that they have an impact origin.
- Impact glass can preserve ancient signs of life -- and as such deposits exist on the Martian surface today -- this opens up a potential new strategy in the search for ancient Martian life.
- This analysis suggests glass deposits are relatively common impact features on Mars.
- These areas could be targets for future exploration.
- Hargraves, one of the craters containing glass, called is near the Nili Fossae trough, a 650 km (400-mi)-long depression that stretches across the Martian surface. The region is one of the landing site contenders for NASA's Mars 2020 rover, a mission to cache soil and rock samples for possible return.
- Nili Fossae trough is already of scientific interest because the crust in the region is thought to date back to when Mars was a much wetter planet. T
- he region also is rife with what appear to be ancient hydrothermal fractures, warm vents that could have provided energy for life to thrive just beneath the surface.
- MRO has been examining Mars with CRISM and five other instruments since 2006.
- This significant new detection of impact glass illustrates how we can continue to learn from the ongoing observations by this long-lived mission. ##

## Mars has belts of glaciers consisting of frozen water

[www.marsdaily.com/reports/Mars\\_has\\_belts\\_of\\_glaciers\\_consisting\\_of\\_frozen\\_water\\_999.html](http://www.marsdaily.com/reports/Mars_has_belts_of_glaciers_consisting_of_frozen_water_999.html)

12 April 2015 – Mars has distinct polar ice caps, but Mars also has belts of glaciers at its central latitudes in both the southern and northern hemispheres.

- A thick layer of dust covers the glaciers, so they appear as surface of the ground, but radar measurements show that underneath the dust there are glaciers composed of frozen water.
- New studies have now calculated the size of the glaciers and thus the amount of water in the glaciers – "the equivalent of all of Mars being covered by more than one meter of ice."
- The results are published in the scientific journal, Geophysical Research Letter.
- Several satellites orbit Mars and on satellite their images, researchers have been **able to observe the shape of glaciers just below the surface.**
- For a long time we didn't know if the ice was frozen water (H<sub>2</sub>O) or carbon dioxide (CO<sub>2</sub>) or just mud.
- Radar measurements from **Mars Reconnaissance Orbiter**, show that it is **water ice.**

### How thick is the ice and do the glaciers resemble glaciers on Earth?

- Niels Bohr Institute researchers have calculated this with radar observations and ice flow modelling.

### Data combined with modelling

- Radar measurements spanning ten years back in time show how thick the ice is and how it behaves.
- A glacier is a big chunk of ice and it flows and gets a form that tells us something about how soft it is.
- Comparing this data with how glaciers on Earth behave, we have been able to model the ice flow
- Earlier studies have identified thousands of glacier-like formations on Mars.
- Glaciers are located in belts around Mars between the latitudes equivalent to just south of Denmark's location on Earth. – in both northern and southern hemispheres.
- From some areas on Mars there is detailed high-resolution data, and sparse data from other areas.
- By supplementing the sparse data about the flow and form of the glaciers from the very well studied areas, we have been able to calculate how thick and voluminous the ice is across the glacier belts.

### Ice could cover the entire planet

- The ice in the glaciers is equivalent to over 150 billion cubic meters of ice – that much ice could cover the entire surface of Mars with 1.1 meters of ice.
- The ice at the mid-latitudes is therefore an important part of Mars' water reservoir.
- That the ice has not evaporated out into space could actually mean that the thick layer of dust is protecting the ice.
- The atmospheric pressure on Mars is so low that water ice simply evaporates to become water vapour.
- But the glaciers are well protected under the thick layer of dust. ##

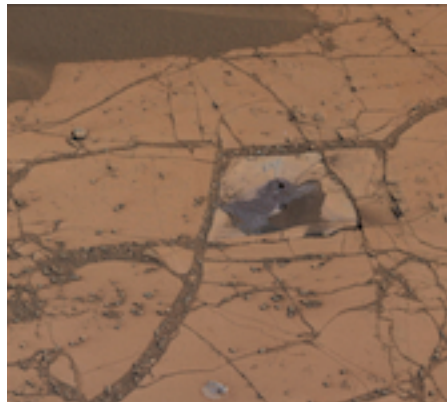
**Editor:** For a long time, many of us have feared that Mars,- except for the lower water ice portion of its polar caps. was dry. Now we know that at snorthern and southern middle latitudes, there is an abundant source of water to serve a considerable settlement population, this lode protected from evaporation by layers of dry soil.

Next, in order To plan where and where not to settle, is a good map of these hidden "glaciers."

On other grounds such as fascinating scenery as in the equator-hugging Valles Marinaris, and in high air pressure deep basins in which we might first learn to fly on Mars, we may or may not have sub-surface glaciers. We need that map! ##

## Mars Life Search: Iron-Rich Rocks Could Be Key

24 April 2015 - [www.space.com/29208-mars-life-search-iron-rocks.html](http://www.space.com/29208-mars-life-search-iron-rocks.html)



The first holes drilled by NASA's Mars rover Curiosity revealed significant amounts of hematite, an iron-oxide mineral.

Full size: [http://i.space.com/images/i/000/047/180/original/curiosity\\_holes.jpg?1429849556](http://i.space.com/images/i/000/047/180/original/curiosity_holes.jpg?1429849556)

- A robotic mission's search for life on Mars may seem worlds away from human scientists wandering around hot springs in Yellowstone National Park.
- But a study of Yellowstone's hot springs has revealed new clues about how organic materials might get preserved in similar environments on Mars, bettering our chances of finding possible signs of life.
- Most studies have focused on the preservation of organic material in silica-rich rocks— the primary source of tiny fossils on Earth that can only be seen with a microscope.
- But some researchers are looking at how iron-rich rocks can also contain possible signs of life.
- Their Yellowstone hot springs study found that iron could either preserve or react with organic material in a way that helps form a fossil record.
- Such findings counter previous assumptions that iron-rich rocks would destroy organic material through the chemical reaction known as oxidation.
- Many microbes like to 'eat' organic compounds, especially **certain lipids**, and can destroy the bulk of the organics before they have a chance to get preserved.
- Iron can rapidly entomb or bind to the organics, making them unavailable to 'eat.'
- Lipids are organic molecules that typically form the cell walls and other parts of living organisms on a microscopic scale.
- Lipids don't provide much identifying information about organisms compared to information of DNA.
- But unlike fragile DNA, lipids have the advantage of potentially leaving their mark for billions of years.
- Lipids can also hold clues about how microorganisms responded to environmental changes.
- Samples were taken from both the active Chocolate Pots hot springs in Yellowstone National Park [NW Wyoming] and an "extinct" iron-silica hot spring nearby that had long since dried up. \
- In a sediment core from the active hot spring, researchers found preserved lipid molecules called 2-methylhopanoids belonging to cyanobacteria, a group of bacteria that converts sunlight into energy.

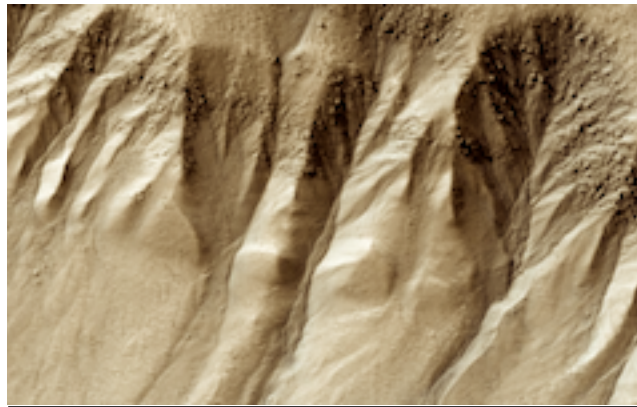
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- They found preserved fragile lipids, such as fatty acids from the cyanobacteria that typically serve as food for other microbes, or are otherwise rapidly destroyed after the cells die.
- It was discovered that the cyanobacterial fatty acids were being preserved in the iron deposits — and were not produced by a deeper chemotrophic community — that forced us to consider ways in which iron may preserve rather than destroy the lipids.
- The iron-rich hot springs may have helped preserve organic molecules such as lipids in several ways.
  - (a) iron reacts chemically with oxygen and lowers oxygen levels in the water, which prevents oxygen-dependent bacteria from consuming all the organic material such as lipids.
  - (b) iron may block some enzymes that help break down organic material after microorganisms die
  - (c) iron can even chemically bind with organic molecules to help preserve them.
- Robotic missions to Mars have found no signs of active hot springs.
- The Spirit rover discovered evidence of hydrothermal deposits in the Home Plate region that indicated an active hydrothermal system when the current dry, dusty Mars was younger and held more water.
- NASA's Mars Science Laboratory Rover, Curiosity, has spent time exploring iron-rich rocks located on Hematite Ridge within Gale Crater.
- The study's findings could eventually help future Mars missions — such as NASA's Mars 2020 rover — hone in on iron-rich rocks that could hold clues to any organic molecules that once existed.
- But they also may be relevant to studies of ancient life on Earth.
- This work may support a renewed interest in sampling ancient iron deposits on Earth (e.g., Precambrian iron formations) to search for evidence of microbial life, regardless of their low organic carbon content, and may support analysis of organics in iron deposits on Mars, such as Hematite Ridge in Gale Crater. ##

## Did Mars Have Flowing Water 500,000 Years Ago?

6 May, 2015 - [www.space.com/29324-mars-life-flowing-water-recent-past.html](http://www.space.com/29324-mars-life-flowing-water-recent-past.html)



A spectacular example of gullies on Mars, at roughly 71° S

- Could water have carved channels on Mars as recently as 500,000 years ago?
- If that's the case, it would boost the case for relatively recent life on the Red Planet.
- Abundant evidence shows that Mars was wet early in its 4.5-billion-year history
- New research, after some 15 years of observations by Mars Reconnaissance Orbiter, suggests that the water comes in cycles, with **opportunities for life to take a hold in between long, cold ice ages.**
- MRO's **High Resolution Imaging Science Experiment (HiRISE)** camera gave the first high-definition look at the planet's surface.
- NASA's Mars Global Surveyor spacecraft's Mars Orbiter Camera previously discovered gullies.
- Almost immediately a new feature popped out — **gullies** which look almost exactly ones on Earth that shaped by water.
- The leading hypothesis is that Mars' gullies were formed by flowing water
- Some research suggests carbon dioxide frost contributes to gully modification.
- Older gullies may be remnants of a time when liquid water was possible at these locations as the atmosphere was thicker and more sunlight was hitting the poles, moving the ice from to mid-latitudes.

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### Hundreds of gullies

- A survey of more than 200 gullies show them to be more abundant in Mars' southern hemisphere.
- A followup study of northern gullies will show if the features are consistent across both hemispheres.
- The gullies did not all form at the same time.
- Water flowed on Mars and created the gullies, with fan-shaped deposits at the mouth of the channels.
- Over time, meteorites and dust altered the landscape, then water flowed again and left more deposits, sometimes on top of the older ones.
- Absolute ages are difficult to estimate from orbit as measuring the half-life of radioactive elements — a method for dating rocks exactly — is not possible from a distance.
- Collecting such measurements requires a rover.
- Scientists can estimate ages, however, based on how many craters have formed in a given area.
- In general, the more craters a surface has, the older it is.
- Climate change caused by variations in the tilt of Mars' poles may be trigger the periodic water flows.
- As the pole changes tilt, sunlight hits different areas of the planet, causing the ice to migrate from the poles to more "temperate" latitudes.
- Currently, Mars is in a position where liquid water is unlikely to flow at gully locations.
- Climate models and gully observations predict that water flowed as recently as 500,000 years ago.

### Implications for life

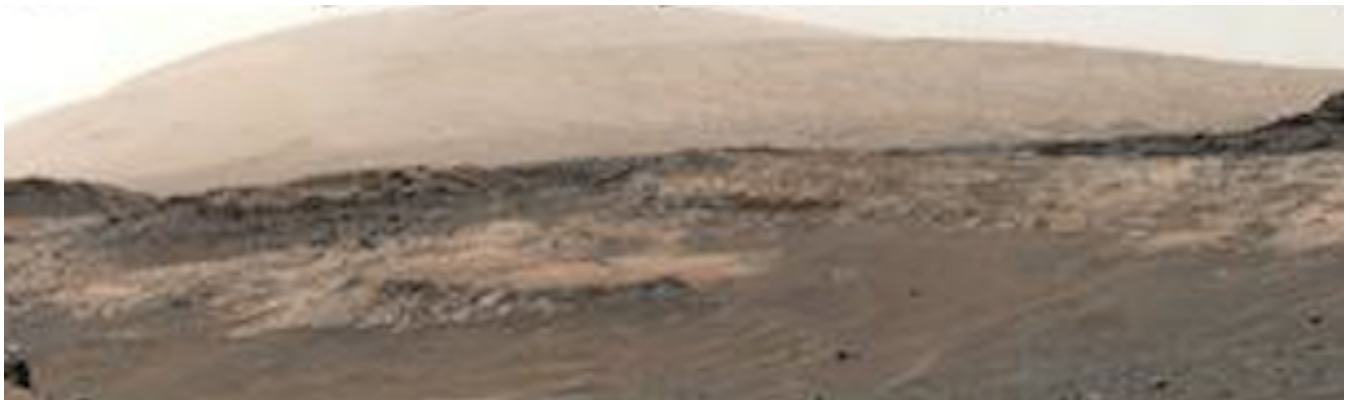
- We don't know yet if life ever existed on the Martian surface.
- Water may have flowed for long period, but whether the water was hospitable is an open question.
- We don't know how acidic it was, or how much water there was.
- What the study does point to, is a **wider timespan for life to arise**.
- Numerous observations of Mars in recent decades have also shown evidence of a potential **ancient shoreline** where an ocean might have been.
- Opportunity, Spirit and Curiosity rovers have all found signs of ancient water in the rocks
- Curiosity rolled through the site of an ancient lake-and-stream system that could have supported microbial life, if any existed billions of years ago.

### The only way to prove that water came more recently is to get a rover down into a gully.

- Current landing technology, however, isn't designed to do that well.
- Mars' atmosphere is much thinner at high altitudes where gullies are present, and parachutes useless.
- There's a risk that a rover could slip on the slope if controllers misdirected it.
- Smaller spacecraft would be lighter under their parachutes and more nimble on the surface ##

## Slippery Slopes on Mars Send Curiosity Rover on Detour

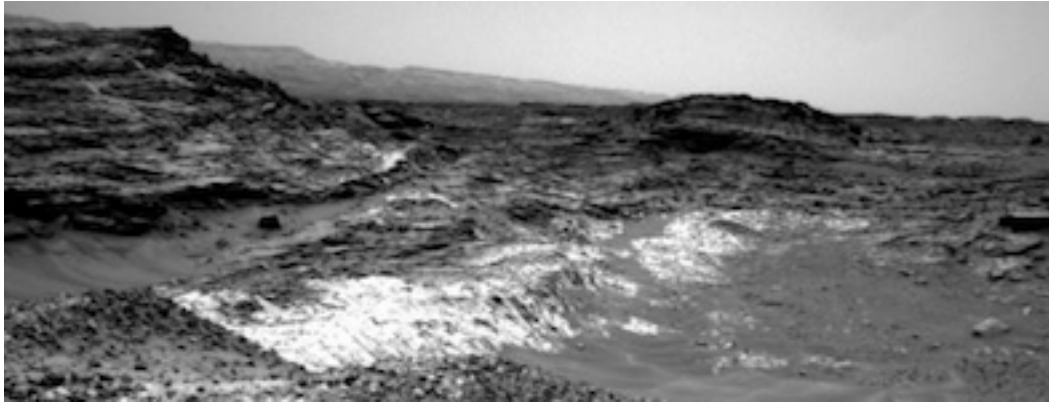
23 May 2015 = [www.space.com/29475-mars-rover-curiosity-slippy-slopes.html](http://www.space.com/29475-mars-rover-curiosity-slippy-slopes.html)



This image, captured by NASA's Mars rover Curiosity on May 10, 2015, shows rough terrain on the way to an outcrop (light-colored rock in middle distance). Curiosity's handlers decided not to traverse this terrain and took a different route instead.

NASA's Mars rover Curiosity has found a new route to some interesting rocks after its original path proved too difficult to traverse.

- Scientists want the rover to check out a "geological contact" where two different rock units meet.
- Curiosity tried to reach such a contact earlier this month, but its six wheels slipped too much during three out of four drives between May 7 and May 13
- Polygonal sand ripples have caused Curiosity a lot of drive slip in the past, but there appeared to be terrain with rockier, more consolidated characteristics directly adjacent to these ripples
- So Curiosity was programmed to drive around the sand ripples onto what we expected to be firmer terrain that would give Curiosity better traction.
- Unfortunately, this terrain turned out to be unconsolidated material also.
- So the rover team decided to map out a new route using images captured by Curiosity and Mars Reconnaissance Orbiter (MRO) circling the Red Planet since 2006.
- This alternate path would allow Curiosity to examine a similar contact to the west.



Curiosity took this photo of a Martian outcrop where pale rock meets darker overlying rock. Such "geological contacts" can shed light on the environmental conditions that produced each type of rock.

- A 21 m (72-ft) drive on May 21st, during which Curiosity climbed up a hill and dealt with 21° slopes, brought the rover close to this contact
- The geological contact contains light-colored rocks similar to those that Curiosity has already studied near the mountain's base, as well as darker material less familiar to the rover team.
- The rover's main goal is to determine if Mars could ever have supported microbial life.
- Mission scientists have already answered that question in the affirmative, determining that the area near Curiosity's landing site was a habitable lake-and-stream system billions of years ago.
- The rover is now climbing up Mount Sharp's foothills, reading the rocks for clues about how the Red Planet's climate and surface conditions have changed over time. ##

## UAE opens space center to oversee mission to Mars

[www.marsdaily.com/reports/UAE\\_Opens\\_Space\\_Center\\_to\\_Oversee\\_Mission\\_to\\_Mars\\_999.html](http://www.marsdaily.com/reports/UAE_Opens_Space_Center_to_Oversee_Mission_to_Mars_999.html)

23 April, 2015 – The **United Arab Emirates** (UAE) opened the Mohammed bin Rashid Space Center on April 23 to oversee preparations of the country's Mars exploration probe mission.

- The MBRSC is affiliated with the Emirates' institution for advanced science and technology, established in 2006 by the UAE government. The center is assigned to "further research, projects and space investigation, in a manner that supports the UAE's drive to develop this sector and to promote national capacity related to space information and science."
- The UAE would become a space hub in the emirate's preparation strategy for when oil reserves run out.

## United Arab Emirates on track to send probe to Mars in 2021

[www.marsdaily.com/reports/UAE\\_says\\_on\\_track\\_to\\_send\\_probe\\_to\\_Mars\\_in\\_2021\\_999.html](http://www.marsdaily.com/reports/UAE_says_on_track_to_send_probe_to_Mars_in_2021_999.html)

6 May, 2015 – Oil-rich **United Arab Emirates** is pressing ahead with plans to send the first Arab unmanned probe to Mars by 2021, naming it "Hope"

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- The probe will leave Earth in 2020 on a mission "designed to complement the science work of other missions and fill important gaps in human knowledge."
- "The mission "represents hope for millions of young Arabs looking for a better future".
- The size and weight of a small car, the probe will reach a speed of 126,000 km (78,000 mi) per hour on the 600 million kilometre journey, which will take around 200 days.
- The spacecraft will orbit Mars until at least 2023 and send back data to be analysed by experts in the UAE and shared with more than 200 institutions worldwide.
- Its **unique orbits** and **unique instruments** will produce **entirely new types of data** that will enable scientists to build "the first truly holistic models of the Martian atmosphere."
- These models will help unlock more mysteries of the Red Planet, such as why its atmosphere has been decaying into space to the point that it is now too thin for liquid water to exist on the surface.
- UAE investments in space technologies had already topped 20 billion dirhams (\$5.4 billion, 4.8 billion euros).
- The UAE, a seven-emirate federation formed in 1971, will become the ninth country in the world with space programmes to explore the Red Planet, according to the statement. ##

## NASA Advisory Council Wants to Cancel Asteroid Redirect Mission and Send it to Phobos Instead

10 April, 2015 – <http://nasawatch.com/archives/2015/04/nasa-advisory-c-5.html>

The NASA Advisory Council (NAC) today unanimously adopted a finding that it thinks

- NASA should change the Asteroid Redirect Mission (ARM)
- To a mission that would go all the way to Mars and thus be more closely aligned with the goal of sending humans there.
- NAC chairman Steve Squyres stressed that it is a **finding, not a recommendation**,
- and **requires no action from NASA**.
- NASA's existing concept for ARM responds to Obama Administration policy
- and NAC recommendations at odds with Administration policy have little value,
- Since NASA must implement what it is told to do."

**Editor:** *our personal feeling is that the NAC suggestion makes the most sense.*

## Is This 'International Flag of Planet Earth the One We'll Plant on Mars?

20 May 2015 - [www.space.com/29452-international-flag-planet-earth-design.html](http://www.space.com/29452-international-flag-planet-earth-design.html)

<https://vimeo.com/127694736>

A Swedish university student has created a design for an "International Flag of Planet Earth" that could be planted on alien worlds during future human exploration missions.



**Left Above:** Artist's conception of an astronaut planting the International Flag of Earth

**Right Above:** The proposed International Flag of Planet Earth by student Oskar Pernefeldt of Beckmans College of Design in Stockholm, Sweden.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

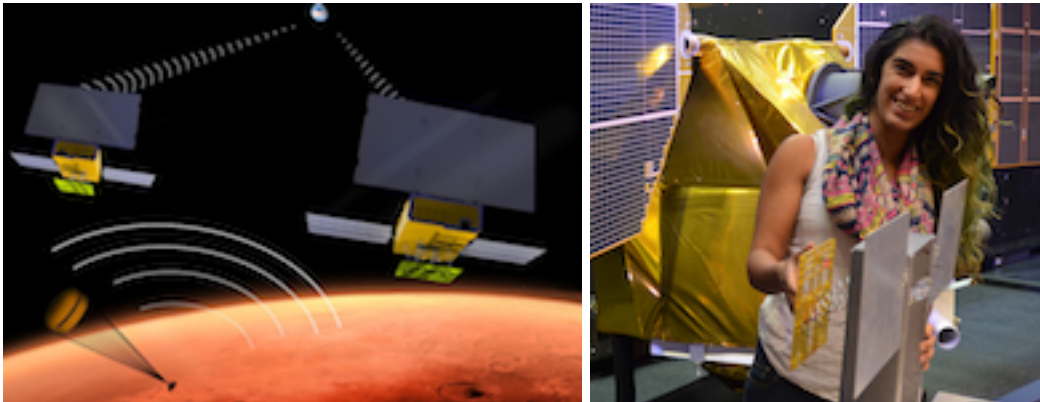


- The student's design features several interlocked white circles on a blue background.
- The flag is intended to remind people that we all share planet Earth, regardless of nationality.
- Space probes are more than representatives of countries. "They are representatives of planet Earth,"
- International cooperation will likely be a big part of any future human missions to Mars and other far-flung destinations, not least because of the high costs associated with such an undertaking.
- While the project website does not mention any plans by space agencies to use the international flag, several pictures depict it being used on spacesuits, on a Mars base and in Antarctica. ##

## NASA to send First Interplanetary CubeSats on Next Mission to Mars

[www.nasa.gov/press-release/nasa-prepares-for-first-interplanetary-cubesats-on-agency-s-next-mission-to-mars/](http://www.nasa.gov/press-release/nasa-prepares-for-first-interplanetary-cubesats-on-agency-s-next-mission-to-mars/)

12 June, 2015 – NASA's next mission to Mars – a stationary lander in 2016 – will include two CubeSats.



**Left:** NASA's two small MarCO CubeSats will be flying past Mars in 2016 just as NASA's next Mars lander, InSight, is descending through the Martian atmosphere and landing on the surface. MarCO, for Mars Cube One, will provide an experimental communications relay to inform Earth quickly about the landing.

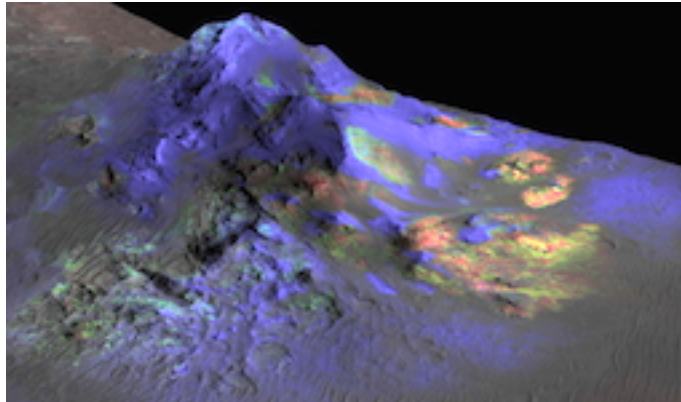
**Right:** The full-scale mock-up of NASA's MarCO CubeSat

- These will be the first CubeSats to fly in deep space.
- If this flyby demonstration is successful, the technology will provide NASA the ability to quickly transmit status information about the main spacecraft after it lands on Mars.
- The **twin communications-relay CubeSats**, being built by the Jet Propulsion Laboratory (JPL), constitute a technology demonstration called **Mars Cube One (MarCO)**.
- The basic CubeSat unit is a box 10 cm (4 in) square. Larger CubeSats are multiples of that unit.
- **MarCO's design is a six-unit CubeSat.**
- MarCO will launch in **March 2016** along with NASA's **IN**terior Exploration using **Seismic Investigations, Geodesy and Heat Transport (InSight)** lander. InSight is NASA's first mission to understand **the interior structure of Mars.**
- The two CubeSats will separate from the Atlas V booster after launch and travel along their own trajectories to the Red Planet. After release from the launch vehicle, MarCO's first challenges are to deploy two radio antennas and two solar panels. The high-gain, X-band antenna is a flat panel engineered to direct radio waves the way a parabolic dish antenna does. MarCO will be navigated to Mars independently of the InSight spacecraft, with its own course adjustments on the way.
- If the MarCO demonstration succeeds, it could lead to a "bring-your-own" communications relay option for use by future Mars missions in critical few minutes between atmospheric entry and touchdown.
- CubeSats are a viable technology for interplanetary missions, and feasible on a short development timeline, this platform could lead to many other applications to explore and study our solar system. ##

## Martian 'Impact Glass' Could Potentially Preserve Signs of Life

24 June, 2015 – [www.space.com/29756-impact-glass-preserve-mars-life.html](http://www.space.com/29756-impact-glass-preserve-mars-life.html)

- Newly discovered deposits of glass on Mars resulting from meteorite impacts may be an ideal place to search for signs of life..



A 3D view of Alga Crater on Mars — one of the locations where impact glass was found.

- Impact glass forms when a meteorite strikes the surface of a planet or moon, melting surrounding rock into glass. While the impact itself is very destructive, the glass can preserve "biosignatures" – traces of life that are there before the impact takes place.
- A 2014 study found organic molecules and plant matter formed millions of years ago in Antarctica.
- This work done showed us that glasses are potentially important for preserving biosignatures
- The glass was detected in images from Mars Reconnaissance Orbiter (MRO). This was a challenge as from a distance, the spectrum of impact glass doesn't stand out well against the landscape.
- To simulate what Mars impact glass may look like, powders and rocks of a similar composition were put in an oven to create the glass, and the spectral composition measured.
- Using an algorithm, a similar spectral signature was found in data from MRO's Compact Reconnaissance Imaging Spectrometer for Mars on the central peaks of craters formed after impact.
- One of the landing-site contenders for the Mars 2020 rover includes a region with impact glass, called Hargraves, near the Nili Fossae trough, a 650 Km (400-mi)-long depression.
- The region is also of interest as the crust may have been created when Mars was a wetter planet. ##

## Earth and Mars May Have Shared Seeds of Life

June 25, 2015 – [www.space.com/29759-earth-mars-share-seeds-of-life.html](http://www.space.com/29759-earth-mars-share-seeds-of-life.html)

**Could Mars, of all places, be the place to look for early life on Earth?**

- This intriguing thought is taken seriously by astrobiologists as they consider the conditions in the early days of the Solar System when planets experienced frequent bombardments by asteroids and comets resulting in debris exchange between one body and the other.
- We might be able to find evidence of our own origin in the most unlikely place, and this place is Mars.
- Studying life in extreme conditions on Earth might help improve the search for signs of life on Mars.
- We might find traces of our own origin in studying Mars.

### Throwing rocks

- Mars has a similar size and composition to Earth. During the period of the Late Heavy Bombardment, about 3.8 to 4 billion years ago, both planets were pummeled with asteroids and comets, which may have also provided the water for Earth's oceans.
- Earth and Mars were, in a sense, connected to each other by the violence of this era and may have been "throwing rocks at each other" for a very long time.
- If life spawned on one planet, it could have clung to one or more of these samples and traveled to the other, a process called "panspermia." Early Earth life could have made it to a "friendly" Mars.

- Today Mars is as bleak and barren as Earth's most desolate deserts. With its thin atmosphere and almost completely waterless surface, any life that landed on Mars today might not take hold.
- When life appeared on the Earth, Mars did have an ocean, volcanoes, lakes, and deltas.
- But unlike Earth, Mars quickly lost its hold on habitability.
- Because Mars lacks a protective magnetic field, the sun's solar wind stripped it of its atmosphere and exposed the surface to bombardment from cosmic rays and ultraviolet (UV) light.
- Most of the water left the surface, escaped into space. Only a few pockets remain on the surface today, at the poles, while some water may lurk beneath the ground.
- While life on Mars' surface may be impossible today, it might still be hiding underground.

### **A time machine**

- One region on Earth that may show traces of this life-giving bombardment lies at the top of the Andes Mountains in Chile. Volcanic lakes fill the cone of the volcano, making it a unique analogue to Mars. The region's elevation is 5,800 m (19,000 ft) where UV rays more easily pierce a thin atmosphere.
- At this altitude, this lake experiences the same conditions as those on Mars 3.5 billion years ago.
- A dive into the interior of one such lake showed that "Life is everywhere, absolutely everywhere" sh.
- Yet the amount of life in the lake can be deceiving. 36% of the samples were of only three species.
- There is a huge loss in biodiversity. Those three species are the ones that have survived so far.
- If life exists on Mars, it is likely to be similarly lacking in biodiversity. Only the hardiest microbes may have survived the planet's decline.
- These conditions have driven the algae within to adapt, giving the water a reddish cast.
- On Earth, a score of 11 in the UV Index, which provides a forecast of the expected risk of overexposure to the sun's ultraviolet radiation, is considered to be extreme.
- During UV storms, the UV Index at the lake can reach as high as 43, the highest UV radiation levels measured on Earth. The water is so clear that the algae have nowhere to hide from the deadly radiation, so they must find other ways to protect themselves, developing their own sunscreen.
- While the lakes give some insight into what could be happening on Mars in the past, they don't suggest what could have happened to organisms on the planet when there were no pools left to hide in.
- When surface water is lost, microbes have only one solution left — they go underground.
- In addition to studying pools at high altitude, the team also examined microbes that seek shelter from the sun's radiation. Semi-translucent rocks were found with microbes hiding beneath, while still taking some energy from the sun.
- Studying these organisms can help scientists searching for life on Mars with rovers such as Curiosity.
- If there was life on Mars 3.5 billion years ago, it had to use the same strategy to protect itself.

### **'Our legacy'**

- Mars isn't the only place life might thrive in the solar system. A subsurface ocean could exist on Jupiter's moons Europa and Ganymede, and on Saturn's moons Titan and Enceladus. The team is developing science exploration strategies for these icy moons, where microbes may have evolved.
- Unlike Mars, such moons would have had a more difficult time exchanging material.
- Mars and Earth could have a common root to their tree of life, but beyond Mars, it's not that easy.
- If we were to discover life on those those moons, it would be different from ours.
- Organic material, wherever found, is going to tell us about environment, complexity, and diversity.
- DNA, or any other information carrier, will tell us about adaptation, evolution, survival, planetary change, and about the transfer of information.
- All together, the findings will tell us why what started as a microbial pathway sometimes ends up as a civilization or sometimes ends up as a dead end.
- Within our solar system, these questions could be answered in the not-too-distant future by our own generation. ##

## HUMANS TO MARS

### Radiation and Boredom: Manned Mars Mission Faces Challenges

9 April, 2015 - [/www.space.com/29064-manned-mars-mission-radiation-boredom.html](http://www.space.com/29064-manned-mars-mission-radiation-boredom.html)

Humanity has long dreamed of visiting Mars, and has made some progress toward that goal in recent decades. But a lot of logistical and biological problems still need to be worked out.

- NASA aims to get astronauts to the vicinity of the Red Planet by the mid-2030s.
- The question is, what's it going to be like on the way?
- Astronauts will need to bring **food, water and other resources** needed for the 6-9-month journey.
- Their bodies will need to be able to withstand the **reduced gravity** and increased **radiation** in deep space, and deal with the **boredom**.

#### Long periods in zero gravity.

- Rotating a spacecraft to produce artificial gravity would be expensive and require a lot of untested engineering,
- So how do we keep the human body healthy in a microgravity environment for long durations?
- We evolved in a 1-G environment. If you take that away for a long time, muscles will begin to atrophy, bone density will decrease and the immune system will become depressed,.
- Some of these problems are being studied already. NASA astronaut Scott Kelly and Russian cosmonaut Mikhail Kornienko have embarked on the first-ever yearlong mission to the ISS.
- (A Russian cosmonaut spent a full year some years back on board the Soviet Mir Space Station.)

#### Then there's the radiation:

- Mars-bound astronauts will be exposed to much stronger radiation in deep space than that found within Earth's magnetosphere.
- Some studies suggest that women may be more susceptible than men to harmful effects of radiation,
- Yet women are generally smaller and eat less than men, so it could be preferable to send women.
- Of 500 people who've flown in space, fewer than 60 have been women. We don't have as much data.
- No human has ever been that far away from Earth,
- On a Mars mission to Mars, the communication delay with Earth could be up to 22 minutes, reducing contact with NASA in an emergency.

*[Editor: the delay, once on Mars, actually will range from 6-40 minutes depending where Mars was in its orbit relative to Earth.]*

- To keep themselves occupied, the astronauts would most likely conduct experiments along the way to keep the crew to feel like they're focused on [achieving] something, not just hanging around.
- It's a pertinent question. On the HI-SEAS simulated mission [on Hawaii Island], there was "a ton" to do, yet there was a monotony" in the day-to-day routine,.
- When today's astronauts travel to orbit, their day is highly scheduled. But when they do have a moment of free time, they want to look out the window at Earth.
- On the way to Mars, there's nothing to see out there, and "staring into the void" may not help.
- Travellers to Mars will likely have strong psyches, which should help them handle the boredom.
- NASA's astronaut-selection process involves rigorous psychological profiling, picking persons unlikely to cause much drama. ##

### NASA Awards Radiation Challenge Winners, Launches Next Round to Seek Ideas for Protecting Humans on the Journey to Mars

[www.nasa.gov/press/2015/april/nasa-awards-radiation-challenge-winners-launches-next-round-to-look-for-ideas-for/](http://www.nasa.gov/press/2015/april/nasa-awards-radiation-challenge-winners-launches-next-round-to-look-for-ideas-for/) - 16 April, 2015 RELEASE 15-057

NASA awarded \$12,000 to five winners of a challenge to mitigate radiation exposure on deep space missions and launched a new follow-on challenge to identify innovative ways of protecting crews on the journey to Mars.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



- The challenge offers an award of **up to \$30,000 for design ideas to protect the crew on long-duration space missions**. Anyone can participate in the challenge, which will be open Wednesday, April 29 through Monday, June 29, 2015.
- Galactic cosmic rays (GCRs), high-energy radiation that originates outside the solar system are a major issue facing future space travelers venturing beyond low-Earth orbit.
- Exposure to these charged particles that permeate the universe is inevitable during space exploration.
- Missions to Mars will require crews to remain beyond the protection of Earth's magnetic field and atmosphere for approximately 500 days and potentially more than 1,000 days
- Learning how to protect human explorers from the effect of exposure to GCRs is a high priority. The five winners selected in the first challenge did not identify a solution that ultimately solves the problem of GCR risk to human crews.
- The first place idea did provide a novel approach to using and configuring known methods of protection to **✓ save substantial launch mass and ✓ lower launch costs over multiple missions**.
- The other winning submissions all provided solid proposed configurations on known approaches and were supported with sound engineering and mathematics.

#### **NASA received 136 submissions. The four selected winners are:**

- 1st place (\$5,000): George Hitt, assistant prof: Physics and Nuclear Engineering at Khalifa University, United Arab Emirates, for his novel idea on **reusing a shield that could be placed in a Mars Transfer Orbit**
- 2nd Place (\$3,000): Ian Gallon, retired researcher in electro-magnetics of Bridport, England, for his **mathematical details on what it would take for an active radiation mitigation system to function well**.
- 3rd Place (\$2,000): Olivier Loido, freelance engineer of Toulouse, France, for his **concepts for a launch configuration and deploying an array of magnets**.
- 4th Place (\$1,000 each): Markus Novak, recent graduate from Ohio State University of Dublin, Ohio, for his **creation of safe areas through particle trajectory simulations**, and Mikhail Petrichenkov of Russia for **concept of operations making use of NASA Storm Shelter work**.

#### **NASA's goal is to identify key solutions that will**

- Reduce crew members' total radiation dose from exposure to GCRs on long duration deep space missions by at least a factor of four.
- In a continued effort to achieve that goal, NASA has developed a **second challenge that asks the public for ideas** on optimal configurations of active and passive solutions to provide crew members maximum protection.
  - ✓ **Active protection** uses **magnetic or electrostatic fields** to deflect the harmful radiation,
  - ✓ **Passive protection** uses **material layering to shield the crew from the GCRs**. ##

## NASA Contest Wants Your Ideas to Keep Astronauts Safe on Mars

7 May, 2015 – [www.space.com/29345-nasa-journey-to-mars-challenge.html](http://www.space.com/29345-nasa-journey-to-mars-challenge.html)  
<https://www.innocentive.com/pavilion/NASA>.

NASA is asking the public for ideas on how to keep Red Planet astronauts safe that **require minimal resupplies** from Earth.

- The "Journey to Mars Challenge" will give a \$5,000 award **to each of the three winning participants** who describe an original idea that could assist the human exploration of Mars.
- The proposal must be
  - ✓ **technically achievable**, ✓ **economically sustainable**, ✓ **minimize reliance on support from Earth**
- This could include **shelter, food, water, breathable air, communication, exercise, social interactions and medicine**
- Participants should **consider innovative and creative elements beyond these examples**
- Because launch costs are considered one of the key barriers to space exploration generally — and Mars exploration, especially — NASA says it could use **some ideas on what to bring on these missions and how often to resupply them**.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- **The resupply aspect is especially important** because resupply opportunities to Mars would happen only every 250 days; the respective orbits between Earth and Mars line up infrequently.
- The agency is looking for **ideas backed up by a strategy** — "a process to develop, test, implement and operate the system or capability."
- In recent months, NASA publicly repositioned its human exploration program as a series of stepping stones to Mars. ##

## Could 'Green Rust' Be A Catalyst For Martian Life?

[www.marsdaily.com/reports/Could\\_Green\\_Rust\\_Be\\_A\\_Catalyst\\_For\\_Martian\\_Life\\_999.html](http://www.marsdaily.com/reports/Could_Green_Rust_Be_A_Catalyst_For_Martian_Life_999.html)

28- May, 2015 - Mars is a large enough planet that astrobiologists looking for life need to narrow the parameters of the search to **those environments most conducive to habitability**.

- NASA's Mars Curiosity mission is now exploring such a spot right at its landing site around Gale Crater, where the rover has found extensive evidence of past water and is gathering information on methane in the atmosphere, a possible signature of microbial activity.

### Where would life most likely gain energy from its surroundings?

- One possibility is in an environment that includes "green rust," a partially oxidized iron mineral. A fully oxidized iron "rust" - one exposed to oxidation for long enough - turns orangey-red, similar to the color of Mars' regolith. When oxidization is incomplete, however, the iron rust is greenish.
- Thus there are two different "redox states," or types of iron with different numbers of electrons in the same mineral. This difference between the two iron redox states could allow the mineral to take in or give up electrons and thus act as a catalyst.
- Green rust can absorb and concentrate nutrients, and can also accept and donate electrons for life.

### Digging deep

- One major challenge in the search for life on Mars is that its surface is highly oxidized. On Earth, green rust oxidizes quickly when exposed to air, and its composition is changed in only an hour.\
- However, the lack of oxygen on Mars makes this a slower process.
- Green rust could occur beneath the oxidized surface, perhaps only a centimeter or half-inch deep as revealed by Curiosity.
- Probes on the way to Mars, such as NASA's InSight lander set to arrive in 2016, will include drills.
- Another is the European Space Agency's ExoMars rover, expected to launch in 2018.
- A major focus of current NASA missions on Mars is finding out where water has flowed in the past.
- NASA's Curiosity, Opportunity and Spirit rovers **have all found rocks that form in the presence of water**, such as the red iron oxide mineral hematite, as well as select sulfates and clays.
- Several orbiting spacecraft have seen gullies, in which water may have once flowed on the surface.

### Probing by laser

- Laser Raman spectroscopy, a technique which will be included on ESA's ExoMars and NASA's Mars 2020 missions, may detect green rust.
- The technique involves directing a laser beam at a sample and then collecting and analyzing the light that is scattered from the spot to identify its molecular composition and structure.
- The scattered light contains fingerprint spectral features that allow us to determine the molecular makeup and mineralogy of the sample.
- We need a better understanding of where green rust will occur and how it can support habitability.
- The JPL Icy Worlds team recently received a 2nd 5-year NASA Astrobiology Institute grant to study the habitability of icy worlds, including an investigation into how green rust might drive prebiotic chemistry, or chemistry that is a precursor to life.
- Green rust could have acted as a proto-enzyme to convert energy currencies on early Earth,.
- Green rust is especially interesting in this regard because it is a double layered hydroxide that can sandwich all sorts of interesting components relevant to life in between these layers, such as phosphates, DNA, amino acids and proteins. ##

## Methane in Mars Meteorites Suggests Possibility of Life

16 June, 2015 – [www.space.com/29674-mars-meteorites-methane-life-search.html](http://www.space.com/29674-mars-meteorites-methane-life-search.html)

Methane, the simplest organic molecule and a potential sign of primitive life, has been found in meteorites from Mars, adding weight to the idea that life could live off methane on the Red Planet.

- This discovery is not evidence that life exists, or has ever existed, on Mars
- But methane is an ingredient that could potentially support microbial activity in the Red Planet.
- This colorless, odorless, flammable gas was first discovered by ESA's Mars Express probe in 2003.
- Much of the methane in Earth's atmosphere is produced by life, such as cattle digesting food. However, there are ways to produce methane without life, such as volcanic activity.
- To shed light on the nature of the methane on Mars, scientists analyzed rocks blasted off Mars by cosmic impacts that subsequently crash-landed on Earth as meteorites. About 100 kg (220 lbs ) of Martian meteorites have been found on Earth.
- The scientists focused on six meteorites from Mars that serve as examples of volcanic rocks there, collecting samples about one-quarter of a gram from each.
- All the samples were taken from the interiors of the meteorites, to avoid terrestrial contamination.
- All six released methane and other gases when crushed, probably from small pockets inside.
- The biggest surprise was how large the methane signals were..
- Chemical reactions between volcanic rocks on Mars could release methane.
- Although the dry thin air makes Mars' surface hostile to life, the planet is probably more habitable under its surface. If methane is available underground, microbes could live off it, just as some bacteria do in extreme environments on Earth.
- We have not found life, but have found methane that could potentially support subsurface microbes.
- The Curiosity rover discovered a fleeting spike of methane at its landing site last year. ##

## Astronauts Need Flexible Spacesuits for Mars

[www.space.com/29769-spacesuit-technology-mars-exploration.html](http://www.space.com/29769-spacesuit-technology-mars-exploration.html)

25 June, 2015 – The next few decades could see humans reach an asteroid, the Moon, even Mars.



NASA's Z-2 spacesuit design could undergo tests aboard the Space Station by the early 2020s.

- The current spacesuits used on the Station will likely need replacing to get those exploration jobs done,
- Today's suits are designed for microgravity work. They would make walking in substantial gravity difficult, because the lower torso of the suit is stiff, making it hard to bend at the waist.
- Better mobility would be needed for doing geologic fieldwork.
- They must also improve on the Apollo suits when one had to bounce to move around on the Moon,
- The Apollo suits were also clumsy because they served multiple purposes, including spacewalks.
- The key will be giving the suits **more flexibility in the lower body**, allowing astronauts to **bend, twist and move around to pick up rocks** and other samples on Mars or other worlds.
- Astronauts shouldn't need to fight to stay stable because their leg joints are too inflexible.

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### ISS testing of futuristic spacesuit

- One of the new advanced prototype spacesuits is a prototype called the Z-2. In April 2014, NASA released the design for the future spacesuit based on a public vote. The chosen cover layer has electro-luminescent wiring and a gray coloring.
- Some changes from current NASA spacesuits include a design for walking, and a **rear-entry hatch** for astronauts to put on the suit.



- One of the big lessons learned, was the viscosity of the resin selected for the composite components was not going to work, But there was a backup resin available that they are now working with.
- Construction of Z-2 should be finished by the end of September. After three months of testing to make sure the spacesuit is ready, 2016 will likely see vacuum chamber and Neutral Buoyancy Lab tests.
- Based on the results, NASA will construct a more realistic prototype called the Z-3 that, among other things, would be able to connect to a portable life-support system to keep astronauts alive in space.
- Testing for Z-3 in space is expected to take place on the ISS around 2020-21.

### Smart suits

- Future spacesuits will make it easier for astronauts to understand how the spacesuit is holding up.
- Military experiments in digital camouflage (using materials like the e-ink in Amazon Kindle displays) could be extending to suit surfaces, helping to regulate temperature, for example,
- Micrometeoroid protection: instead of using many layers, using a self-healing polymer, or some kind of active-repair technology on the suit's surface, a polymer or patch could be catalyzed electrically,
- Futuristic spacesuits could include "**shape memory**" to better fit to an astronaut's body shape.
- Sensors in the gloves could make it easier for astronauts to "feel" what they are touching and integrating tiny cameras to help the astronauts see around them.
- It also will be easier for people at home to follow along with the experience of walking on Mars or floating near an asteroid, even more so than the live broadcasts of the Apollo era, de
- In fact, an astronaut's ability to share the experience with people back on Earth could be a primary reason for sending humans to distant locations. ##

**Recommended Book:** Nicholas de Monchaux, an associate design professor at the University of California, Berkeley, who wrote a book called "Spacesuit: Fashioning Apollo" (The MIT Press, 2011).

## Destination Mars: NASA Asks Where Astronauts Should Land

25 June, 2015 - [www.space.com/29766-mars-astronauts-landing-sites-nasa-workshop.html](http://www.space.com/29766-mars-astronauts-landing-sites-nasa-workshop.html)

NASA has already begun trying to figure out where its first Mars astronauts should touch down, about two decades before the pioneers are scheduled to launch toward the Red Planet.

- NASA will hold a workshop in Houston this October to kick off serious discussions about possible landing sites for NASA's first manned Mars mission, hopefully in the mid- to late 2030s.
- **Wanted: "exploration zones" roughly 100 km (62-mi) wide that would be scientifically interesting and possess enough resources, such as subsurface water ice, to support human explorers.**

"A hot debate"

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- The October meeting will start exactly the conversation we need to be able for an architect to know what a station on Mars would look like, and how [it] would operate.
- NASA plans to study the most promising exploration zones in depth using the Mars Odyssey spacecraft and Mars Reconnaissance Orbiter (MRO).
- We are going to need high-resolution imagery over the whole exploration zone,
- MRO has captured high-res images of just % of the Martian surface to date.
- Detailed information about the potential exploration zones' mineralogy will also be crucial to mission planners, providing clues about what resources the sites may harbor.
- **"The first Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars"** will take place at the Lunar and Planetary Institute in Houston from Oct. 27-30. ##

## ADVANCED ROCKET TECHNOLOGY FOR MARS AND BEYOND

### NASA Selects Companies to Develop Super-Fast Deep Space Engine

[www.spacedaily.com/reports/NASA\\_Selects\\_Companies\\_to\\_Develop\\_Super\\_Fast\\_Deep\\_Space\\_Engine\\_999.html](http://www.spacedaily.com/reports/NASA_Selects_Companies_to_Develop_Super_Fast_Deep_Space_Engine_999.html)

8 April, 2015 – NASA announced it will partner with a variety of companies to create more advanced space technology – including a new engine that could get humans to Mars in less than 40 days.

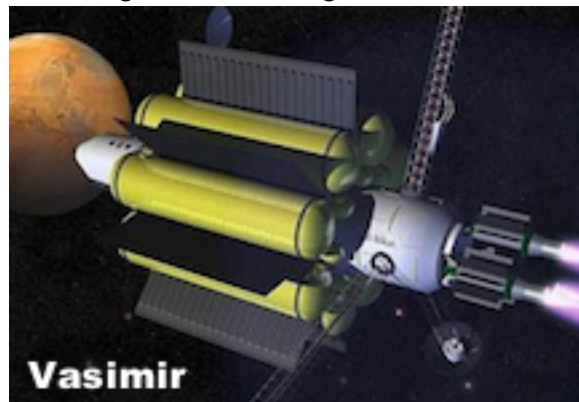


Illustration of how a Mars bound Vasimir powered rocket would look like

- Texas-based Ad Astra Rocket company, a member of NASA's 12 Next Space Technologies for Exploration Partnerships (NextStep), boasted their VASIMR engine can get humans to Mars in 39 days.
- The **Variable Specific Impulse Magnetoplasma Rocket (VASIMR)** is an electromagnetic thruster for a spacecraft using radio waves and magnetic fields to ionize and heat a propellant to generate thrust.
- The engine rocketed to fame several years ago when it was touted as able to cut a journey to Mars down from months to weeks, even though it requires a nuclear power source
- After its successful test in 2013 the agency is considering employing it.
- Ad Astra is happy to be joining forces with NASA in the final steps of its technology maturation.
- Over a three year period, NASA will give Ad Astra around \$10 million dollars to fully develop a new version of the VASIMR engine to be flight ready.
- With the successful demonstrations of their new VX-200-SS prototype, able to fire continuously for more than 100 hours, NASA may employing this propulsion system on future excursion to Mars.
- Meanwhile, other commercial partners such as Boeing, Lockheed Martin, and Dynetics Inc were in place to explore other possibilities on Mars.
- This work ultimately will allow humans to venture further into the solar system. ##

### NASA Brings in Small Business for Further Development of Hypervelocity Vehicles

[www.nasa.gov/press-release/nasa-brings-in-small-business-for-further-development-of-hypervelocity-vehicles](http://www.nasa.gov/press-release/nasa-brings-in-small-business-for-further-development-of-hypervelocity-vehicles)

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27 April, 2015 – NASA has awarded the Entry Systems Technology Research and Development (ESTRAD) contract to Analytical Mechanics Associates, Inc., a small business in Hampton, Virginia.

- As NASA continues on its journey to Mars, the **ESTRAD** contract will provide engineering support for the development of **technologies that will be used to design and fabricate vehicles that travel at hypervelocities in the atmosphere of Earth and other bodies in the solar system, such as Mars.**
- This **cost-plus-fixed-fee hybrid contract** has an **indefinite delivery/indefinite quantity** provision.
- The contract has a five-year period of performance, consisting of a two-year base with a value of \$2.2 million and three one-year options. The **total estimated contract value is \$43 million.**
- The work performed under this contract is managed by the Entry Systems and Technology Division at NASA's Ames Research Center in Moffett Field, California. ##

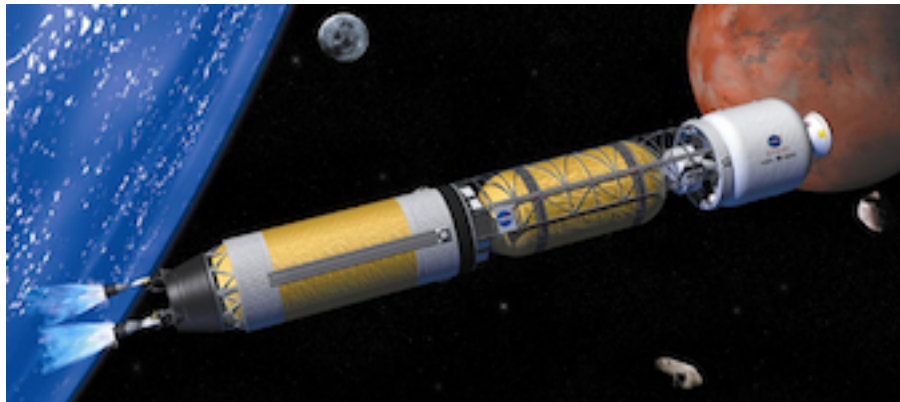
## NASA Chief Wants to Cut Mars Travel Time in Half

2 June, 2015 – [www.space.com/29540-manned-mars-mission-propulsion-technologies.html](http://www.space.com/29540-manned-mars-mission-propulsion-technologies.html)

Older story: [www.space.com/23445-mars-missions-superfast-propulsion-incredible-technology.html](http://www.space.com/23445-mars-missions-superfast-propulsion-incredible-technology.html)

CANOGA PARK, Calif. — Getting astronauts to Mars will take all the spacefaring expertise the United States can muster, including advanced propulsion technologies such as **solar-electric engines** and perhaps even **nuclear rockets**, according to NASA Administrator Charlie Bolden.

- In statements made during a visit to the Aerojet Rocketdyne plant here May 28th, Bolden stressed that he'd like to slash the travel time required to send astronauts to Mars from about 8 months to 4.



Artist's concept of a nuclear thermal rocket. Such vehicles could help humanity get to Mars and other planets in the solar system. Credit: NASA

- Superfast propulsion would help limit astronauts' radiation exposure during the trek to Mars and reduce the amount of water, food and other "consumables" such a mission would require.
- Bolden, Aerojet Rocketdyne's CEO and president Scott Seymour and Julie Van Kleeck, the company's Vice President of Advanced Space & Launch Systems, discussed the advanced solar-electric propulsion systems (SEP) the company has been working on.
- Aerojet Rocketdyne is currently building 5-kilowatt (kW) engines for NASA robotic missions. "Fifteen kW would be the next step, then cluster them together ... then, long term, 50 to 100 kilowatts."
- The limiting power of solar-electric propulsion has been the power to drive it. Aerojet Rocketdyne has partnered with different entities around the country in looking [at] how to get more energy density onto a solar cell. The more power we can get, the larger we can make the engine and its capability.
- The advantage of solar-electric propulsion is that it can fly nearly forever as opposed to the traditional liquid-fueled rocket engines that propel the vast majority of NASA's spacecraft.
- But SEP units — which generate thrust by accelerating charged atoms and molecules out the back of a spacecraft — are limited in what they can accomplish.
- Nuclear rockets such as the NERVA (Nuclear Engine for Rocket Vehicleerformance) system were studied by NASA in the 1960s and 1970s

- There is some technology being looked at regarding the fuels aspects of Nerva, to make it lower cost and safer for the future. (NERVA was scrapped in 1972, despite successful ground-firing tests and promising performance.)
- Bolden said that he wanted to put more money into these advanced space-only systems, which could potentially be "game changers" — and not just for delivering cargo to Mars.
- Bolden wants game-changing in-space propulsion, with the focus on moving people really fast.
- Putting some money into this is the start. ##

## NASA Announces Journey to Mars Challenge, Seeks Public Input on Establishing Sustained Human Presence on Red Planet

[www.nasa.gov/press-release/nasa-announces-journey-to-mars-challenge-seeks-public-input-on-establishing-sustained](http://www.nasa.gov/press-release/nasa-announces-journey-to-mars-challenge-seeks-public-input-on-establishing-sustained)

5 May, 2015– NASA is inviting the public to write down their ideas, in detail, for developing the elements of space pioneering necessary to establish a continuous human presence on Mars.

1) What do you need to bring along to Mars, and

2) How do you minimize the need for delivery of future supplies in order to establish a sustained human presence on a planet 140 million miles away from Earth?

- This could include **shelter, food, water, breathable air, communication, exercise, social interactions and medicine**
- Participants are encouraged to consider **other innovative and creative elements**.
- Describe **one or more Mars surface systems or capabilities and operations** that are
  - ✓ needed to achieve this goal and,
  - ✓ are technically achievable
  - ✓ economically sustainable, and
  - ✓ minimize reliance on support from Earth.
- There may be up to **three awards** at a minimum of **\$5,000 each** from a total award pool of \$15,000.
- The goal is **reusable space capabilities, incorporating commercial and international partners**.
- The goal is to build and maintain a permanent human presence in deep space, built to stay.
- Given spacecraft limitations on weight and volume -- and a minimum 500 days between Earth-Mars resupply opportunities -- innovative solutions not dependent on Earth resources are required.
- Submissions should describe the development of capabilities and operational events necessary, in both the near- and long-term, to advance this bold journey.
- Submissions may consist of proposed approaches, capabilities, systems or a set of integrated systems that enable or enhance a sustained human presence on Mars.
- Solutions should include the assumptions, analysis, and data that justify their value.
- Submissions are to include a process to develop, test, implement, and operate the system/capability.
- Submissions will be judged on relevance, creativity, simplicity, resource efficiency, feasibility, comprehensiveness and scalability.
- For more information about the challenge, and details on how to apply, visit:
 

<http://go.nasa.gov/1JONps3>

## Roadmap for Manned Missions to Mars Reaching 'Consensus,' NASA

6 May, 2015 – [www.space.com/29323-nasa-manned-mars-exploration-plans.html](http://www.space.com/29323-nasa-manned-mars-exploration-plans.html)

Despite skepticism in Congress concerning NASA's asteroid-capture project, NASA chief Charles Bolden said "consensus is emerging" about that mission and NASA's plan to send humans to Mars.

- "This plan is clear, affordable, and sustainable,"
- NASA is taking several steps to achieve its stated goal of getting humans to "the vicinity of Mars" (read to Mars' moonlets Phobos and Deimos) by the mid-2030s.

- One NASA astronaut and one Russian cosmonaut recently embarked on a one-year mission on the Space Station to investigate the physiological and psychological effects of long-duration spaceflight.
- NASA is building the 7-person Orion space capsule and the Space Launch System rocket to take a crew beyond Earth orbit for the first time since the Apollo Moon missions of 1969–72.
- Critics have asked NASA to “desist” from the asteroid capture mission to pluck a boulder off a space rock and drag it into orbit around the Moon, to be visited by astronauts by 2025, as a distraction from getting people to Mars, but Bolden sees it as a stepping stone to Mars
- NASA is trying to demonstrate the technologies and the techniques that would allow commercial companies, entrepreneurs and others get to asteroids and mine them.
- NASA also plans to test **solar electric propulsion** during the asteroid mission as a potentially cheaper way to take astronauts through the solar system.

#### Time is of the essence

- This is a period of renewed interest in manned Mars exploration.
- By whatever route NASA chooses to get to Mars, it must back up that plan with a strategy that includes
  - ✓ A launch schedule
  - ✓ Related hardware development
  - ✓ An architecture sophisticated enough for cost estimation
- NASA must update its 2009 Mars Design Reference Architecture to reflect current technology, to harness the current wave of public interest in Mars.

#### The human touch

- NASA is already exploring Mars today with several robotic missions, including Curiosity and Opportunity on the surface, and several craft in orbit, such as Maven
- However successful, these robots can't compete with humans in ingenuity, speed, resourcefulness.
- People are beaded to fix rovers when they break. ##

## Manned Mars Plan: Phobos by 2033, Martian Surface by 2039 ?

9 May, 2015 – [www.space.com/29349-manned-mars-missions-phobos-moon.html](http://www.space.com/29349-manned-mars-missions-phobos-moon.html)  
[www.space.com/23762-manned-mars-mission-ideas.html](http://www.space.com/23762-manned-mars-mission-ideas.html)

Humanity's path to Mars may go through its tiny moonlet **Phobos**.

- An incremental multiple-mission approach to get astronauts to Phobos by 2033, then down to Mars' surface by 2039 could make human Mars exploration technologically and economically feasible,
- NASA can't count on another "John F. Kennedy moment" — the 1961 call by the then-president to land people on the moon “by the end of this decade” — to boost its budget.
- NASA's share of the U.S. budget, – c. 4.5% during the height of the Apollo years; is now less than 0.5%
- The Phobos-first approach would use NASA technology already under development, such as the Orion crew capsule and the Space Launch System (SLS) megarocket, leaving out exotic future technologies such as nuclear thermal propulsion.
- SLS and Orion could fly together initially in 2018, and to launch crews for the first time in 2021.
- Several space tugs, powered by solar-electric propulsion, would be placed in Mars orbit with supplies that future crews could use for landings.
- The mission to Phobos — the larger of two mini moons (Deimos is the other) would require four SLS launches, while a six-day stay on Mars on top of that would bring the total to six liftoffs.
- Keeping the cost of manned Mars exploration down will also require using on site resources, living off the Martian land as much as possible.
- A graduate student's study suggests that using Mars' water, methane and hydrogen for fuel on the journey back to Earth could cut the initial mass sent to low-Earth orbit for a Mars mission by 48%.
- Further, money could be saved by treating Mars exploration as a network of missions with linked objectives, rather than a series of one-offs.
- Common elements among various missions will also save on cost;
- "Commonality: it has to lead and it can't follow. It has to be at the front end of the program." ##

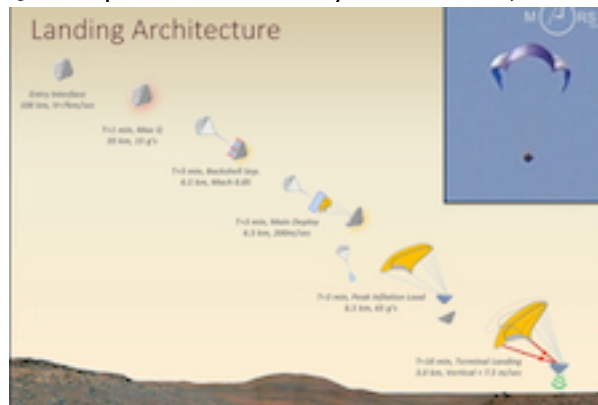


## Hang Gliders on Mars: Innovative Idea to Land Probes on Red Planet

18 May, 2015 – <http://www.space.com/29433-mars-microprobes-parawing-lander.html>

An innovative concept for tiny probes attached to gliders could one day allow small robots to explore intricate locales on Mars that probes never could reach before.

- “MARSDROP” would send two landers to Mars as hitchhikers aboard a larger spacecraft. The landers would then detach and use a steerable parawing to glide the “microprobes” down to Mars’ surface.
- This concept is the brainchild of Rebecca Williams, a senior scientist with the Planetary Science Institute, who collaborated with Matthew Eby from the Aerospace Corporation and a team of engineers led by Robert Staehle at NASA's Jet Propulsion Laboratory in Pasadena, California



This illustration shows how the MARSDROP mission concept would land microprobes on Mars using an entry vehicle and parawing glider. Inset: A MARSDROP prototype under its parawing.

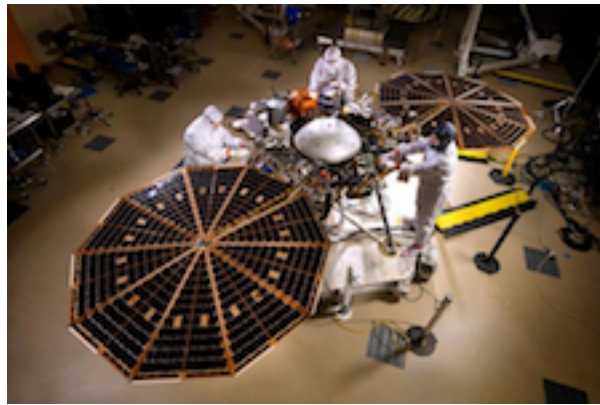
- A prototype version of the MARSDROP re-entry vehicle has already been tested. Using terrain-relative video navigation, microprobes could be steered to within tens of meters of a desired landing spot.
- The probes' small size and precise landing let them explore parts of Mars that larger land rovers like NASA's Curiosity can't reach: Martian canyons, fresh impact-crater sites, volcanic regions and glaciers, at modern geologically active sites such as south-polar geysers, or locations with inferred seasonal release of surface water flows.
- The microprobes would carry a suite of instruments: cameras, weather sensors, seismometers and microscopes that can study minerals and inorganic substances
- The idea is to gather critical data about the surface of Mars before humans can set foot on the planet.
- The probes could provide scientists with new information about Martian surface geology, monitor surface changes, and search for organics or astrobiologically relevant minerals.
- MARSDROP can help lay the groundwork for future human exploration of Mars by characterizing bio-hazards like Martian dust and assessing the availability of key resources such as water from which oxygen and rocket propellant can be made.
- MARSDROP is a cost-effective way to double or triple the number of Mars landers for each mission opportunity.
- If MARSDROP is successful, the technology could also be used on planets with atmospheres thicker than Mars, including Venus and Saturn's moon Titan. ##

## NASA's Next Mars Lander Begins Tests for 2016 Launch

28 May, 2015 – <http://www.space.com/29503-nasa-insight-mars-lander-begins-testing.html>

NASA's next robotic Mars explorer is assembled and undergoing testing ahead of its launch March 2016

- Engineers at Lockheed Martin Space Systems have finished building the InSight lander and have begun testing it, to make sure it can handle the rigors of launch and the harsh environment of deep space.
- This phase takes nearly as long as assembly, but we want to make sure we deliver a vehicle to NASA that will perform as expected in extreme environments.
- The environmental testing regimen is designed to wring out any issues with the spacecraft



InSights solar arrays are deployed during an April 30, 2015 test inside a clean room at Lockheed Martin Space Systems in Denver. InSight is scheduled to launch in March 2016.

- The 7-month test program will expose InSight to powerful vibrations, extreme temperatures and various air-pressure regimes, to ascertain how the lander will perform during launch, during the long cruise to Mars and on Mars' surface,.
- The \$425 million InSight mission — whose name is short for Interior Exploration using Seismic Investigations, Geodesy and Heat Transport — is scheduled to arrive on Mars, September 2016.
- The lander will use several different science instruments to study Mars' crust, mantle and core to better understand Mars' interior structure shed light on how rocky planets in general form and evolve.
- NASA also plans to launch two tiny CubeSats along with InSight, to help relay data to Earth during the spacecraft's entry, descent and landing sequence. The two Mars Cube One (MarCO) won't go into orbit about Mars but will continue journeying through deep space after InSight lands. ##

## 5 Mars Mission Radiation Shield Ideas Win NASA Challenge

28 May, 2015- [www.space.com/29512-mars-mission-radiation-nasa-challenge.html](http://www.space.com/29512-mars-mission-radiation-nasa-challenge.html)  
[www.space.com/21353-space-radiation-mars-mission-threat.html](http://www.space.com/21353-space-radiation-mars-mission-threat.html) – Infographic

NASA has awarded prize money to five members of the public for their ideas about how to limit astronauts' radiation exposure during journeys through deep space.

- Crews on their way to Mars and other distant destinations will venture beyond Earth's protective atmosphere and magnetic field, so they will be subject to relatively high levels of radiation both from the sun and from galactic cosmic rays
- A roundtrip Mars mission would require between 500 and 1,000 days of deep-space travel, making radiation protection a priority and explaining why NASA mounted the recent challenge.
- The five winning proposals were selected from a pool of 136 submissions. The overall winner will get \$5,000, while the other four awardees will split \$7,000, NASA officials said.
- None of the five prize winners, which were announced last month, presented solutions that could reduce astronauts' galactic cosmic ray exposure by a factor of four — NASA's long-term goal
- But agency officials said the proposals were promising and innovative.
- A follow-on challenge will take place through June 29, with up to \$30,000 available in prize money.
- The new challenge will solicit ideas for (a) active protection (using magnetic or (b) electrostatic fields to act as a shield) or passive protection relying on layered materials.
- "We look forward to seeing what people will come up with in this next challenge to find the optimal configuration for these different protection approaches,"

**The winners of the radiation challenge's first round are:**

- 1st place (\$5,000): George Hitt, assistant professor of physics and nuclear engineering at Khalifa University, United Arab Emirates, for proposing a **reusable shield that could be placed in an orbit between Earth and Mars.**
- 2nd Place (\$3,000): Ian Gallon, retired researcher in electromagnetics of Bridport, England. He provided **mathematical calculations for an active radiation mitigation system.**

- 3rd Place (\$2,000): Olivier Loido, freelance engineer of Toulouse, France. He proposed a **launch configuration and a magnet array deployment.**
- 4th Place (\$1,000 each): Markus Novak, recent graduate from Ohio State U. of Dublin, Ohio, who found **safe areas for travel after performing particle trajectory simulations.** Also, Mikhail Petrichenkov of Russia, who described **how operations could work using a NASA storm shelter.**

## New “Mars Polar” Project Aims to Establish a Human Colony on Mars

[www.marsdaily.com/reports/New\\_Project\\_Aims\\_to\\_Establish\\_a\\_Human\\_Colony\\_on\\_Mars\\_999.html](http://www.marsdaily.com/reports/New_Project_Aims_to_Establish_a_Human_Colony_on_Mars_999.html)

28 May, 2015 – MarsPolar, a newly started international venture is setting its sights on the Red Planet.

- The project consisting of specialists from Russia, United Arab Emirates, Poland, U.S. and Ukraine
- Their bold idea s to establish a human settlement on Mars' polar region, where the water ice is.
- The targeted area could be very interesting in terms of alien life hunting
- The plan is to create the colony around 2029 with a crew of 4–6 astronauts arriving, every 2 years.
- SpaceX's Falcon 9 or Falcon Heavy rocket could launch the mission and its Red Dragon craft would deliver cargo and crews to Mars.
- But before MarsPolar sends a manned mission, several spacecraft will be delivered to the Red planet with **habitats and supplies** for future colonists.
- A Mars rover is also on schedule to be launched in 2018, 2 years after the start of NASA's InSight mission on which the teams' robot would be based on.
- Who will develop the rover is still the open question – every interested company is welcome.
- In 2020 the Mars Transportation Vehicle will take 35 tons of payload to the Low Earth Orbit. MTV will carry food, water and oxygen supplies as well as more than 20 tons of hardware for future Mars explorers like: habitats, life support system, solar arrays, spacesuits or water extraction unit.
- A month after the arrival of this first MTV's stage to LEO, the second stage with fuel tanks up to 40 tons and the additional engine will be launched to LEO and docked to the first stage.
- When the MTV arrives in orbit of Mars, the Dragon will be undocked and directed back to Earth. The rest of the MTV will aerobrake into orbit around Mars and will land with the help of a parachute.
- According to the team's website, the life support systems and the water extractor will be turned on, so the breathable atmosphere will be ready when the second ship with the crew will arrive to Mars.
- Every 2 years another spacecraft could be send to the Red Planet as there is only one launch window every 26 months, when Mars and Earth line up and the journey takes only 6–7 months.
- The first crew that will start its interplanetary trip to Mars will spend a short time, from one week to one month, in Earth orbit, awaiting the second Falcon Heavy launch with the additional booster unit.
- Month after the arrival of the second MTV's stage to LEO, the stage with fuel tanks up to 40 tons and the additional engine will be launched to LEO and docked to the first stage.
- Then the spacecraft, using the booster unit, will be inserted toward Mars.
- The Landing site for the crew will be chosen near the position of the second unmanned mission.
- The astronaut selection process is also still in its infancy. The team has only specified the basic criteria not shutting the door on the vast number of future wannabe Martians.
- Candidates should have what it takes, a vocation and adequate predispositions for the job.
- MarsPolar team is currently going through the organizational processes.
- They want to establish its base, the MarsPolar Space Center, somewhere in the UAE and their website is registered in Dubai.
- The team's first goal on the long road to Mars is to create a legal private space company in the UAE.
- MarsPolar is different from Mars One and it would not compete with the famed one-way mission. The new venture differs in terms of preparations for the mission and also the costs would be much lower.
- MarsPolar's mission would also not include a return trip for tcolonists, at least for next ten years.
- he team has prepared a concept of the Earth Return Vehicle (ERV), which may be used in the future.
- To secure the funding for the ambitious pioneering journey to Mars and to begin the necessary activities like building the space center, MarsPolar will rely mainly on donations, investments and future business income opportunities. ##

**Editor:** While **Mars Polar** is better thought out than **Mars One**, both are poorly thought out.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

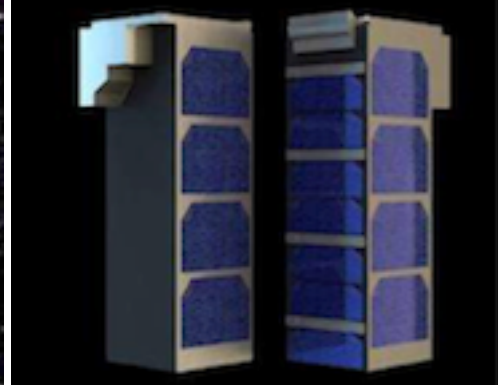


[The articles below have been summarized by the editor. For the full text, see the links cited.]

## ASTEROIDS

### CubeSats offered deep-space ride on ESA asteroid probe

26 February 2015 – [www.phys.org/news/2015-02-cubesats-deep-space-esa-asteroid-probe.html](http://www.phys.org/news/2015-02-cubesats-deep-space-esa-asteroid-probe.html)



**L:** Launching October 2020, ESA's Asteroid Impact Mission spacecraft will be our first mission to a binary system – the paired Didymos asteroids – a comparatively close 11 million km to Earth in 2022. The 800 m-diameter main body is orbited by a 170 m Moon. AIM will perform high resolution visual, thermal and radar mapping of the moon. It will also put down a lander

**R:** A pair of triple-unit CubeSats. ESA's 2020 Asteroid Impact Mission spacecraft will have room to carry six CubeSat units – potentially single-unit miniature spacecraft but more probably a pair of larger CubeSats as seen here.

- ESA will give CubeSats a ride to a pair of asteroids: the ultimate hitchhiking opportunity: .
- CubeSats are among the smallest types of satellites: formed in standard cubic units of 10 cm per side, they provide affordable access to space for small companies, research institutes and universities. One-, two- or three- or more unit CubeSats are already being flown.
- Teams of researchers and companies from any ESA Member State are free to compete.
- When the Asteroid Impact Mission (AIM) is launched in October 2020, the selected CubeSats will become Europe's first to travel beyond Earth orbit.
- AIM has room for a total of six CubeSat units – that might mean six different one-unit CubeSats could fly, or it might turn out that two three-unit CubeSats will be needed for good scientific return.
- "Wanted: innovative ideas for CubeSat-hosted sensors to boost and complement scientific return."
- The plan is to use these CubeSats, together with AIM itself and its asteroid lander, **to test out inter-satellite communications networking.**
- ESA's SysNova initiative will survey a comparatively large number of alternative solutions.
- This competition framework gives industry and universities the opportunity to work together on developing their scientific investigations in a field that is the technological cutting edge. ##

### NASA Asteroid-Sampling Spacecraft Begins Construction

1 April, 2015 – [www.space.com/28995-nasa-osiris-rex-asteroid-mission-milestone.html](http://www.space.com/28995-nasa-osiris-rex-asteroid-mission-milestone.html)

[www.space.com/20921-why-retrieve-samples-from-asteroids-video.html](http://www.space.com/20921-why-retrieve-samples-from-asteroids-video.html)

[http://en.wikipedia.org/wiki/101955\\_Bennu](http://en.wikipedia.org/wiki/101955_Bennu)

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**Osiris-Rex** short for **O**rigins **S**pectral **I**nterpretation **R**esource **I**dentification **S**ecurity **R**egolith **E**xplorer, the NASA probe that will snag pieces of a near-Earth asteroid a few years from now is shaping up.

- Osiris Rex has moved from design and development phase to the spacecraft-building stage.
- After almost 4 years in design phase, the probe is now in flight-system assembly stage, scheduled to launch in September 2016.
- According to plan, the probe will rendezvous with a s scheduled to launch in September 2016. If all goes according to plan, the robotic probe will rendezvous with a 500 m (1,650-ft wide asteroid named **Bennu** in 2018, grab at least 60 gm (2.1 oz) of space rock material and bring the sample back to Earth in 2023.



Lockheed Martin technicians in a clean room facility near Denver assembled [NASA's OSIRIS-Rex](#) asteroid-sampling spacecraft

- The mission aims to shed light on the Solar System's early days and how Earth came to possess the carbon-containing building blocks of life.
- As Bennu is a potentially hazardous asteroid, Osiris-Rex could also have planetary-defense applications.
- Osiris-Rex's just-met milestone, called Key Decision Point-D (KDP-D), is a type that comes after a series of independent reviews into a mission's finances, schedule and technical aspects.
- 1,650-foot-wide) asteroid named Bennu in 2018, grab at least 2.1 oz (60 gm) of space rock material and bring the sample back to Earth in 2023.
- In the next six months, Lockheed Martin technicians will install many subsystems on Osiris-Rex's spacecraft "bus," including its avionics, power and telecommunications systems and the mission's five scientific instruments.
- The probe should be ready to begin environmental testing this fall.
- Osiris-Rex will be the first U.S. asteroid-sampling mission. Japan's Hayabusa spacecraft collected pieces of the asteroid Itokawa and returned them to Earth in 2010. The nation's Hayabusa 2 mission, another sample-return effort, launched in December 2014 toward a space rock called 1999 JU3 and is expected to reach the asteroid in 2018.
- NASA is also developing its **Asteroid Redirect Mission**, which aims to pluck a boulder off a large asteroid and drag the piece into lunar orbit, where it can be visited by astronauts.
- ARM's current schedule calls for the robotic capture probe to launch in 2020, and for the first astronaut visit to come in 2025. ##

## A Reporter's View: NASA's OSIRIS-REx Asteroid Mission Taking Shape

19 April, 2015 – [www.space.com/29086-nasa-asteroid-mission-osiris-rex-first-person.html](http://www.space.com/29086-nasa-asteroid-mission-osiris-rex-first-person.html)

[pictures: [/www.space.com/20920-nasa-osiris-rex-asteroid-mission-photos.html](http://www.space.com/20920-nasa-osiris-rex-asteroid-mission-photos.html)]

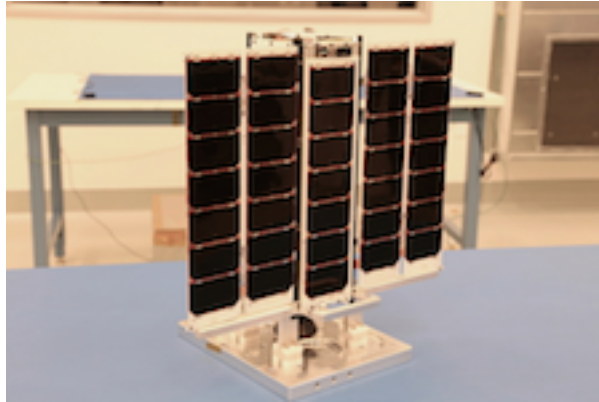
NASA's OSIRIS-REx spacecraft is coming together for a September 2016 liftoff. The **O**rigins, **S**pectral **I**nterpretation, **R**esource **I**dentification, **S**ecurity, **R**egolith **E**xplorer (**OSIRIS-REx**) probe is headed for **asteroid Bennu**, a **carbon-rich** body that could hold clues to the origin of the solar system and host organic molecules that may have seeded life on Earth.

- OSIRIS will return samples of the asteroid, returning the specimens back to Earth for detailed analysis

- Taking off next year, OSIREX will reach **asteroid Benu** in 2018 and return a sample in 2023.
- Over the next several months, spacecraft handlers will install on the OSIRIS-REx structure its avionics, power, telecomm, mechanisms, thermal systems, and guidance, navigation and control.
- Once fully assembled, the probe will undergo rigorous environmental testing this fall.
- Lockheed Martin is building the spacecraft and will provide spacecraft mission operations.
- OSIRIS-REx is the third mission in NASA's New Frontiers Program.
- NASA's Marshall Space Flight Center in Huntsville, Alabama, manages New Frontiers
- NASA's Goddard Space Flight Center in Greenbelt, Maryland, will provide overall mission management, systems, engineering and safety and mission assurance. ##

## Asteroid-Mining Company to Deploy 1st Satellite This Summer

6 May, 2015 - [www.space.com/29321-asteroid-mining-planetary-resources-satellite.html](http://www.space.com/29321-asteroid-mining-planetary-resources-satellite.html)  
[www.space.com/21349-arkyd-the-crowdfunded-selfie-taking-space-telescope-video.html](http://www.space.com/21349-arkyd-the-crowdfunded-selfie-taking-space-telescope-video.html)



The Arkyd 3 Reflight (A3R) technology demonstration spacecraft is shown before launching to the International Space Station

**Photo Gallery** - [www.space.com/15387-asteroid-mining-planetary-resources-gallery.html](http://www.space.com/15387-asteroid-mining-planetary-resources-gallery.html)

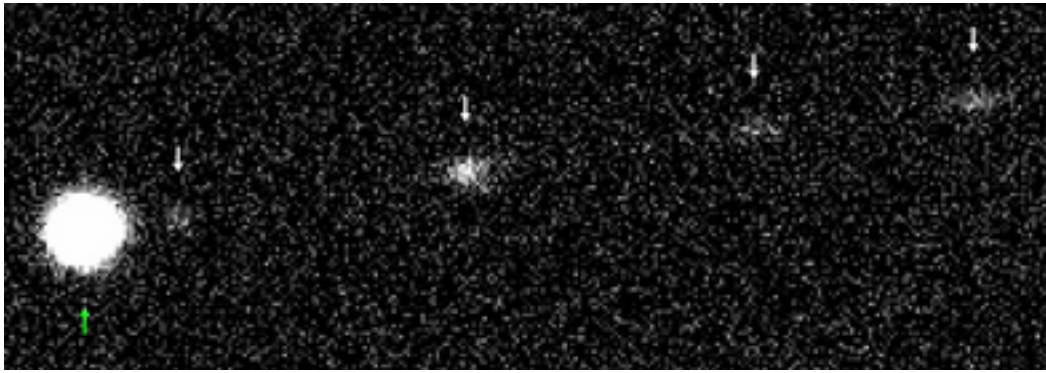
The nascent asteroid-mining industry is set to take its first steps into space this summer.

- Planetary Resources' **Arkyd-3R probe** sits aboard the Space Station, to be deployed sometime in July.
- Once it's flying solo, it will perform a demonstration mission, testing out systems that will enable future probes to study and eventually mine asteroids in deep space.
- "During its 90-day Earth-orbiting mission, it will send back data on the health of its subsystems.
- The "R" in Arkyd-3R stands for "Reflight" - it took two tries to get the spacecraft off the ground.
- The original Arkyd-3 flew aboard the third resupply mission of Orbital ATK's Cygnus freighter, which was lost October 28 when Orbital's Antares rocket exploded seconds after liftoff.
- Planetary Resources and Deep Space Industries, aim to help humanity extend its presence out into the solar system by tapping asteroid resources such as water and precious metals - for profit.
- Water may be key to the entire enterprise, because it can be split into hydrogen and oxygen, the chief components of rocket fuel.
- Asteroid mining could thus lead to the establishment of in-space propellant depots to refuel voyaging spaceships relatively cheaply.
- Planetary Resources aims to achieve its grand vision via a series of incremental steps.
- Arkyd-3R - a cubesat, is to be followed by the twice as large Arkyd-6 later this year.
- Arkyd-6 is part of a line of "ScienceCraft" that will not only test the scientific instruments and deep-space technologies at the heart of our asteroid-prospecting missions, but will also provide a platform that will allow others to fly their mission with Planetary Resources' technologies..
- Arkyd-100 will demonstrate asteroid-observation techniques and technologies from Earth orbit.
- Thereafter, the plan calls for sending other probes out to study space rocks up close. ##

## Freakish Asteroid Likely Spun So Fast It Exploded

9 April, 2015 - [www.space.com/29056-fast-spinning-asteroid-explosion.html](http://www.space.com/29056-fast-spinning-asteroid-explosion.html)

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This image shows "active asteroid" P/2012 F5 in 2014, showing the fragments without the dust trail  
An odd asteroid rotated so fast that it blew itself apart, a new study suggests.

- Using the Keck Observatory in Hawaii, researchers spotted four fragments of the asteroid, and also determined that it completes one rotation every 3.24 hours, fast enough to break apart.
  - Fast rotation may be catapulting dust and fragments in some active asteroids and comets
  - Until now, we couldn't fully test this hypothesis. We didn't know how fast fragmented objects rotate.
  - This could help us better understand mysterious "active asteroids" that shed material like comets do.
- So far, Four of these unusual objects have been found, each 1 km (0.6 mi) wide or smaller.

**Two hypotheses for how such asteroids become active.**

1. They collided at high speed with another minor object.
2. Active asteroids rotate so fast that their centrifugal forces exceed the force of their own gravity.
  - Rotational disruption is the expected final state of the YORP [Yarkovsky–O'Keefe–Radzievskii–Paddack] effect — a slow evolution of the rotation rate due to asymmetric emission of heat
  - The explosion hypothesis has a problem = asteroids that rotate faster that don't exhibit mass loss.
  - With so many pieces of debris flying around in the asteroid belt, collisions could still be a factor.
  - P/2012 F5 lies in the main asteroid belt between Mars and Jupiter. The object was initially identified as a comet when it was discovered in March 2012.
  - But further analysis revealed that all of P/2012 F5's dust apparently came off in a big surge in 2011.
  - This doesn't happen with comets, which instead shed gradually as the sun's energy bleeds dust and gas away from the surface. ##

## NASA Advisory Council Wants to Cancel Asteroid Redirect Mission and Send it to Phobos Instead

10 April, 2015 – <http://nasawatch.com/archives/2015/04/nasa-advisory-c-5.html>

The NASA Advisory Council (NAC) today unanimously adopted a finding that it thinks

- NASA should change the Asteroid Redirect Mission (ARM)
- To a mission that would go all the way to Mars and thus be more closely aligned with the goal of sending humans there.
- NAC chairman Steve Squyres stressed that it is a **finding, not a recommendation**,
- and **requires no action from NASA**.
- NASA's existing concept for ARM responds to Obama Administration policy
- and NAC recommendations at odds with Administration policy have little value,
- Since NASA must implement what it is told to do."

**Editor:** *our personal feeling is that the NAC suggestion makes the most sense.*

## Explosive Culprit? Russian Fireball's Origins Found

9 April, 2015 - [www.space.com/29059-annama-meteorite-asteroid-origin-traced.html](http://www.space.com/29059-annama-meteorite-asteroid-origin-traced.html)  
( [www.space.com/25576-russia-meteor-murmansk-video.html](http://www.space.com/25576-russia-meteor-murmansk-video.html) )



A picture of the Annama meteorite fireball over Russia's Kola Peninsula near the Finnish–Russian border

- A fireball over NE Russia last year may share an orbit with a huge asteroid discovered October.
- The Kola fireball was spotted April 19, 2014, as it lit up the night sky above the Kola Peninsula.
- Its orbit is "disturbingly similar" to the asteroid 2014 UR116, slated to pass by the Moon in 2017.
- The Finnish Fireball Network monitors the sky for meteoroids and fireballs, and eyewitness video helped recreate the meteoroid's trajectory and hunt down meteorite fragments on the ground.
- The international team who analyzed the meteorite's orbit calculated the fireball's size and path through Earth's atmosphere by examining its flight and the meteorite's final impact site.
- A computer model based on these figures was used to estimate the space rock's orbital path.
- The 500 kg (1,100 lb) meteorite is an ordinary H5 chondrite, a type of stony meteorite responsible for 31 percent of Earth's impacts.
- The fragments are called the "Annama meteorite" because the meteorite fell near the Annama River.



- Precise detective work suggests the fireball escaped from the innermost region of the asteroid belt.
- It has an elliptical orbit typical of the Apollo family of near–Earth orbiting asteroids, and it likely came from the same broad source region as the Lost City, Peekskill and Buzzard Coulee meteorites.
- The researchers compared the Annama meteorite's orbit with known near–Earth asteroids.
- Of 12 potential matches, by far the closest match was with the asteroid 2014 UR116.
- The new report does suggest that asteroid 2014 UR116 and the Annama meteorite may be related.
- Streams of asteroid fragments — such as the remnants of collisions — can sail on nearly identical orbits. Tidal forces may stretch out these rocky debris patches over time.
- Asteroids may also fragment from the stress of passing near the planets, the researchers noted.
- The tidal effect on an asteroid, which rapidly rotates under the gravitational field of a planet, can fragment these objects or release large rocks from its surface, which could then become dangerous projectiles at a local scale, such as the one that fell in Chelyabinsk, Russia
- Asteroid 2014 UR116 discovered Oct. 27, 2014, is 400 m (1,312 ft) across,
- Ts not an impact danger ##



## NASA's OSIRIS-REx Mission Passes Critical Milestone

[www.nasa.gov/press/2015/march/nasa-s-osiris-rex-mission-passes-critical-milestone/](http://www.nasa.gov/press/2015/march/nasa-s-osiris-rex-mission-passes-critical-milestone/)  
<http://www.nasa.gov/osiris-rex>

31 March, 2015 – NASA's groundbreaking science mission to retrieve a sample from an ancient space rock has moved closer to fruition. OSIRIS-REx is the first U.S. mission to return samples from an asteroid to Earth. The spacecraft will travel to a near-Earth asteroid, **Bennu**, and bring at least a 60-gm (2.1-oz) sample back to Earth.



### About OSIRIS-REx

“OSIRIS-REx” – Origins Spectral Interpretation Resource Identification Security Regolith Explorer

<http://www.asteroidmission.org> – background: [www.nasa.gov/content/goddard/bennus-journey/](http://www.nasa.gov/content/goddard/bennus-journey/)

The Origins Spectral Interpretation Resource Identification Security -- Regolith Explorer spacecraft will travel to a near-Earth asteroid, called **Bennu** (formerly 1999 RQ36), and bring at least a 59 gm (2.1-oz) sample back to Earth for study.

- Set for launch in late 2016, OSIRIS-REx – will travel to a near-Earth asteroid, “Bennu” and bring at least a 60-gm (2.1-oz) sample back to Earth;
- The spacecraft will reach Bennu in 2018 and return a sample to Earth in 2023.
- It will be the first U.S. mission to return samples from an asteroid.
- OSIRIS-REx is the third mission in NASA's New Frontiers Program. NASA's Marshall Space Flight Center in Huntsville, Alabama, manages New Frontiers for the agency's Science Mission Directorate.
- OSIRIS-REx carries 15 instruments that will remotely evaluate the surface of Bennu.
- The mission will help scientists
  - investigate the composition of the very early solar system and the source of organic materials and water that made their way to Earth,
  - improve understanding of asteroids that could impact our planet.
- The spacecraft structure has been integrated with the propellant tank and propulsion system and is ready to begin system integration in the Lockheed Martin highbay,

### Timeline

- The payload suite of cameras and sensors is in environmental test phase for delivery later this year.
- On March 27, assembly, launch and test operations officially began at Lockheed Martin in Denver.
- The key decision meeting was held at NASA Headquarters in Washington on March 30.
- Over the next several months, technicians will install the subsystems on the main spacecraft structure, comprising avionics, power, telecomm, thermal systems, and guidance, navigation and control.
- The next major milestone is the Mission Operations Review to demonstrate that the navigation, planning, commanding, and science operations requirements are complete.
- The mission's principal investigator will provide overall mission management, systems engineering and safety and mission assurance for OSIRIS-REx.
- Lockheed Martin Space Systems in Denver will build the spacecraft.
- OSIRIS-REx complements NASA's Asteroid Initiative, which aligns portions of the agency's science, space technology and human exploration capabilities in a coordinated asteroid research effort.

- The initiative will conduct research and analysis to better characterize and mitigate the threat these space rocks pose to our home planet.
- Included in the initiative is NASA's Asteroid Redirect Mission (ARM), a robotic spacecraft mission that will capture a boulder from the surface of a near-Earth asteroid and move it into a stable orbit around the Moon for exploration by astronauts, all in support of advancing the nation's journey to Mars.
- The agency is engaging new industrial capabilities, partnerships, open innovation and participatory exploration through the NASA Asteroid Initiative.
- NASA has made tremendous progress in the cataloging and characterization of near Earth objects over the past five years.
- The president's NASA budget included, and Congress authorized, \$20.4 million for an expanded NASA Near-Earth Object (NEO) Observations Program, increasing the resources for this critical program from the \$4 million per year it had received since the 1990s.
- The program was again expanded in fiscal year 2014, with a budget of \$40.5 million. NASA is asking Congress for \$50 million in the 2016 budget.
- NASA has identified more than 12,000 NEOs to date, and 96 % of near-Earth asteroids larger than 1 km
- NASA has not detected any objects of this size that pose an impact hazard to Earth in the next 100 years.
- Smaller asteroids do pass near Earth, however, and some could pose an impact threat. In 2011, 893 near-Earth asteroids were found. In 2014, that number was increased to 1,472.
- In addition to NASA's ongoing work detecting and cataloging asteroids, the agency has engaged the public in the hunt for these space rocks through the agency's Asteroid Grand Challenge activities, including prize competitions.

#### A Fringe Benefit

- During the recent South by Southwest Festival in Austin, Texas, the agency announced the release of a software application based on an algorithm created by a NASA challenge that has the potential to increase the number of new asteroid discoveries by amateur astronomers. ##

### Will Asteroid 2012 TC4 Hit Earth in October 2017 ?

[www.spacedaily.com/reports/Will\\_Asteroid\\_2012\\_TC4\\_Hit\\_Earth\\_in\\_October\\_2017\\_999.html](http://www.spacedaily.com/reports/Will_Asteroid_2012_TC4_Hit_Earth_in_October_2017_999.html)

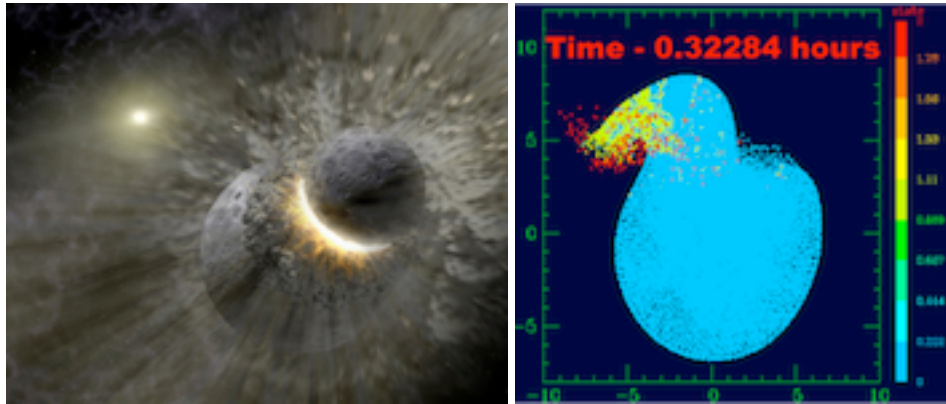
17 April, 2015 – On Oct. 12, 2017, asteroid 2012 TC4 is slated to whizz by Earth dangerously close.

- The exact distance of its closest approach is uncertain, as well as its size.
- Based on observations in October 2012 when the space rock missed our planet, astronomers estimate that its size could vary from 12–40 m (39–128 ft).
- The meteor that exploded over the Russian city of Chelyabinsk in February 2013, injuring 1,500 people and damaging over 7,000 buildings, was about 20 m (66 ft) wide.
- Thus, the impact of 2012 TC4 could be even more devastating. We could see an airburst maybe broken windows, depending on where it hits. (far more likely to hit over countryside than cities.)
- This asteroid was discovered on Oct. 4, 2012 by the Pan-STARRS observatory in Hawaii.
- It gave Earth a close shave passign at 0.247 LD (lunar distance), or 94,800 km (59,000 mi).
- 2012 TC4 is an elongated, rapidly rotating object that has made many past close approaches to Earth.
- Now scientists try to determine the exact path of 2017 fly-by and probability of a possible impact.
- It has a 1 in 1800 cumulative chance that it will hit.
- That the minimum orbit intersection distance is only 0.079 LD (lunar distance), or 94,800 km (59,000 mi) flags it as a possible impactor – “a one in a million chance that it would hit us.”
- The size was estimated from the brightness, but we don't know the reflectivity. So it could be smaller or larger, from 10–40 m. A 40 m iron object would go through the atmosphere and make a crater; a 10 m rocky object would be hardly noticed.”
- “If it's a rocky asteroid and if it hit, the effects would be similar to the Chelyabinsk impact.”
- As of Apr. 12, 2015, there are 1572 “Potentially Hazardous Ssteroids” (PHA) detected.
- “None of the known” PHAs is on a collision course with Earth. ##

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

## Meteorites Help Date the Violent Birth of Earth's Moon

17 April, 2015 - [www.space.com/29136-earth-moon-formation-meteorite-dating.html](http://www.space.com/29136-earth-moon-formation-meteorite-dating.html)



The cataclysmic collision between Earth and a Mars-size object, named “Theia” that forged the Moon may have occurred about 4.47 billion years ago, suggests a study of meteorites with ancient fragments from that cosmic impact.

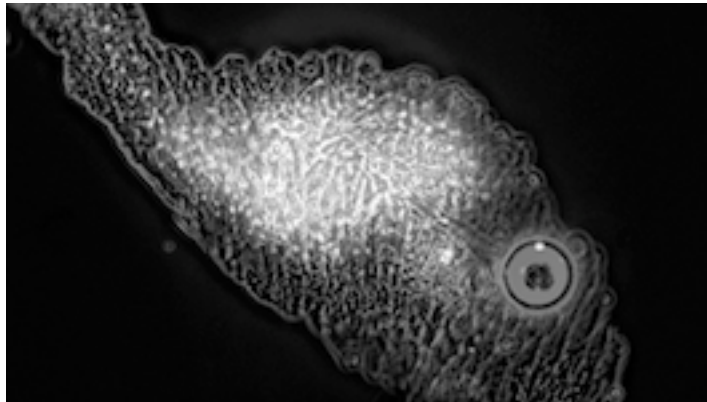
- One day, it may be possible to find samples of what the primordial Earth was like before the giant impact that formed the Moon, or to uncover bits of the impacting rock itself.
- Earth was born about 4.5 billion years ago, and scientists think the Moon formed shortly afterward.
- The leading explanation for the Moon's origin, known as the giant impact hypothesis, suggests that the Moon resulted from the collision of two protoplanets, or embryonic worlds. One of those was the young Earth, and the other was a potentially Mars-size object we have named Theia. The Moon then coalesced from the rubble.
- The precise timeline of this giant impact event is under dispute.
- The ages of the most ancient lunar samples the Apollo astronauts brought back are still debated, since these samples have typically been battered and heated by subsequent cosmic impacts.
- To understand the formation and evolution of our world as well as those in the inner solar system, we need to understand the timing of major events during the planet-formation era.
- To find out more about this giant impact, scientists developed a computer model of the event. They found that the impact not only created a disk of debris near Earth that formed the Moon,
- but it also ejected huge amounts of rubble — as much as several percent of Earth's mass — away from Earth and the Moon.
- The simulations showed that numerous fragments from the Moon-forming impact — hundreds of millions at least 1.6 km (1 mi) long — blasted the asteroid belt, striking asteroids there at speeds of more than 36,000 km/h (22,370 mph), **more than twice as fast as typical crashes in the belt.**
- These collisions would have generated superheated material.
- “Investigators can learn about the explosive device and the explosion itself by studying what happened to the main-belt asteroids as a result.
- From traces left behind, we can tell “who did it, when they did it and how they did it.”
- Researchers deduced that the Moon-forming impact occurred about 4.47 billion years ago, in agreement with many previous estimates.
- We can now use asteroids to tell us about many of the major events that took place in the inner solar system during the planet-formation era.
- This gives us a new window on a time period which has been virtually unknown up to now.
- Trace amounts of the primordial Earth and/or Moon may still be found on asteroids today, or possibly within some of our meteorites.
- We have no rocks older than 4 billion years old on Earth, and no one knows the exact nature of Earth's original building blocks.
- “If future research can uncover examples of this impact in asteroid samples, “possibly by getting them from an asteroid sample return mission like OSIRIS-REx, we would have one of the key pieces of the puzzle explaining why our world is the way it is, and what has changed since its infancy,” ##

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and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

## Earth microbe prefers living on meteorites

<http://news.sciencemag.org/biology/2015/04/earth-microbe-prefers-living-meteorites>



16 April, 2015 – The microbe above is happier living on meteorites than on Earth.

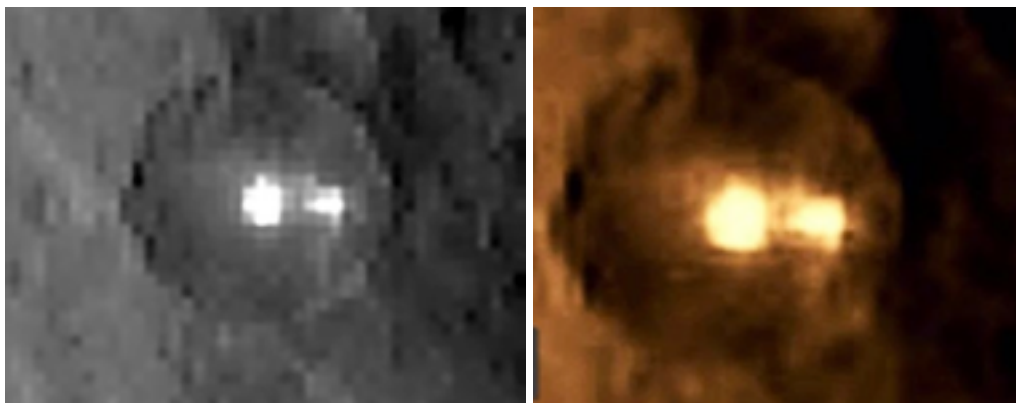
The microscopic organism—an archaea known as *Metallosphaera sedula* (seen as a cluster of tiny dots sitting in the middle of the meteoritic dust particle pictured above)—was originally found in 1989 living in Italy's hot acidic sulfur springs around Vesuvius.

- These so-called “chemolithotrophs” normally **feed on iron and sulfur minerals** in rocks and **leave behind a residue of heavy metals**.
- This makes them useful in mining operations as an environmentally friendly alternative to leaching the metals with toxic chemicals.
- In the lab, the process looks very similar to watching glass jars full of beer ferment with yeast.
- To test these microbes’ “**astrofermiation**” capability, researchers gave them an “energy drink made of powdered meteorite” and recorded how much **nickel** they released in the jars.
- The microbes went on a space dust binge—consuming their samples in only 2 weeks as compared with the 2 months it took for them to munch through their Earth samples.
- **This work could have implications for asteroid mining**, where rare metals embedded in space rocks could be extracted and brought back to Earth for use in technological advancements.
- Future work will include **testing the survivability of the microbes in a vacuum** and **with synthetic martian minerals**. ##

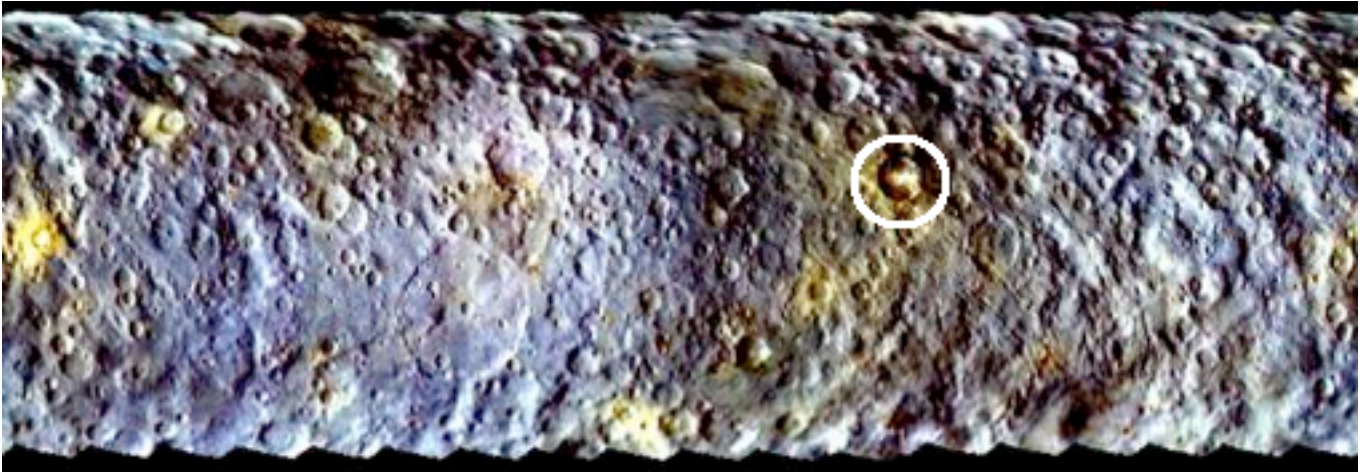
## CERES

### Weird Bright Spots on Dwarf Planet Ceres Still a Mystery in New Maps

15 April, 2015 – [www.space.com/29110-mystery-bright-spots-ceres-dawn-maps.html](http://www.space.com/29110-mystery-bright-spots-ceres-dawn-maps.html)







By far the most detailed (Mercator Projection) map yet of Ceres' surface showing many small craters, no big ones. The map is based on images taken from the Dawn spacecraft which entered orbit in March.

- Strange bright spots on the surface of the Ceres continue to mystify scientists even as NASA's Dawn spacecraft is beaming the best maps yet of the dwarf planet in the asteroid belt.
- The latest photos of Ceres from Dawn, released April 13th, were taken just before the spacecraft entered orbit around the dwarf planet in March.
- Dawn is now in the shadow of Ceres, forcing scientists to wait until later in April before catching their next day lit view of the surface.
- About 10 bright spots on Ceres have been detected in Hubble Space Telescope photos.
- The two most prominent are in a crater about 92 km (57 mi) wide.
- We will have to wait until we get closer to resolve the bright spots before we tell their source
- NASA released new images from Dawn's visible and infrared mapping spectrometer examining the bright spots, as well as a new color map showing Ceres's entire surface.
- Ceres has many craters, **but fewer large ones that scientists expected.**
- The temperatures of the two prominent bright spots vary: one is similar to the surrounding surface, while the other is cooler.
- Ceres was not just another inert rock throughout its history. It was active, with processes that resulted in different materials in different regions.
- We are beginning to capture that diversity in our color images.
- Dawn will begin its extended mapping phase of Ceres on April 23 from a distance of 13,500 km (8,400 mi) from the surface. It will remain with the dwarf planet in 2016. ##

**Editor:** Somehow, my vision of Ceres and my expectation was that the surface would be pretty smooth. Evidently, Ceres (and I am now sure Pluto and Charon too) have been busy "clearing their orbits" - the premature conclusion that they haven't been doing so being the excuse for demoting it (and Pluto-Charon) to the status of "dwarf planet." **Let the "demoters" eat "crater-crow"!** ##

## Dwarf planet' Ceres spawns giant mystery

13 April, 2015 – [www.spacedaily.com/reports/Dwarf\\_planet\\_Ceres\\_spawns\\_giant\\_mystery\\_999.html](http://www.spacedaily.com/reports/Dwarf_planet_Ceres_spawns_giant_mystery_999.html)

First classified a planet, then an asteroid and then a "dwarf planet" with some traits of a moon -- the more scientists learn about Ceres, the weirder it becomes.

- New observations of Ceres have added to the mystery,.
- Astrophysicists have been looking to a 446-million-euro (\$473-million) mission to determine if Ceres is a water-rich planetary "embryo" -- a relic from the birth of the Solar System 4.5 billion years ago.
- But an early batch of data from NASA's Dawn probe, unveiled at a conference of the European Geosciences Union (EGU), may have made the Ceres riddle even greater.

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- In orbit around Ceres since March 6 after a seven-and-a-half-year trek, Dawn peered at two bright spots on its surface expected to be clues to Ceres's chemical and physical ID.
- But the two spots seemed to "behave distinctly differently."
- Spot 1 is colder than its immediate surroundings, Spot 5 is not.
- The spots are two of a dozen or so on that resemble lights shining on a dull grey surface.
- Ceres orbits at some 414 million km (260 million mi) from the Sun, every 4.61 Earth yearst.
- About 950 km (590 mi) wide, it is the biggest object in the asteroid belt -- large enough for gravity to have moulded its shape into a ball.
- With VIR, the Dawn team have been able to put together images at different wavelengths of light.
- One picture, as seen by the human eye, shows Ceres as a "dark and brownish" ball with both white spots clearly visible.
- But in thermal images, Spot 1 is a dark spot on a reddish ball, and cooler than the rest of the surface.
- The biggest surprise was that Spot 5 simply disappeared on the thermal image.
- We have bright spots on Ceres which, from a thermal perspective, seem to behave in different ways.
- Theories about what the spots are range from ice to "hydrated minerals"
- Ice would be difficult to explain, though, as Ceres inhabits a zone not quite distant enough from the Sun to allow "stable ice" on the surface.

### Missing craters

- Also intriguing is that Ceres is very unlike neighbouring Vesta, which Dawn studied in 2011 and 2012.
- Vesta is bright and reflects much of the Sun's light, while Ceres is dark -- a contrast that says these bodies have experienced very different space odysseys.
- The team also found fewer large craters on Ceres than observations of Vesta suggested they should.
- When craters sizes on Ceres were compared to those on Vesta, the number of large craters waa less.
- Pockmarks on the surface did suggest Ceres had a "violent collisional history."
- In short, the case for Ceres as a baby planet that never made it to adulthood remains in limbo.
- More may become clear in the coming months when Dawn, which until now has been on Ceres' dark side, moves closer to probe its surface composition and temperature.
- Ceres was first object in the main asteroid belt to be discovered, in 1801 iand named after the Roman goddess of harvests..
- After more, but smaller objects turned up, Ceres was downgraded to an "asteroid" only to get a status boost in 2006, becoming a "dwarf planet."

## Dawn Probe enters Science Orbit around Ceres

28 April, 2015 – [www.space.com/29235-dawn-spacecraft-dwarf-planet-ceres-orbit.html](http://www.space.com/29235-dawn-spacecraft-dwarf-planet-ceres-orbit.html)



NASA's Dawn probe captured this image of the dwarf planet Ceres' northern terrain on April 14 and 15, 2015, from a distance of about 14,000 miles (22,500 kilometers).

NASA's Dawn probe has reached its first science orbit at Ceres, marking the start of the spacecraft's serious scrutiny of the mysterious dwarf planet.

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and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- Dawn arrived at the science orbit on April 23, spiraling down to an altitude of 13,500 km (8,400 mi) (13,500 km above Ceres. The probe achieved this milestone on schedule, but with a bit of drama.
- Dawn briefly entered into safe mode and awaited further instructions, sent by mission controllers.
- As of April 24, the craft returned to normal operating mode=.
- The \$466 million Dawn mission launched in September 2007, tasked with orbiting and study the two largest objects in the main asteroid belt between Mars and Jupiter — Ceres and the Vesta, 950 km (590 mi) and 530 km (330 mi) wide, respectively.
- Both are believed to be intact protoplanets left over from the planet-formation period
- Investigating them should reveal insights about the solar system's early days.
- Dawn orbited Vesta from July 2011 through September 2012, when it departed for Ceres. The probe arrived at Ceres on March 6, becoming the first spacecraft ever to orbit a dwarf planet and the first to circle two celestial objects beyond the Earth-Moon system.
- Dawn will map Ceres' surface in detail and attempt to determine what the dwarf planet is made of.
- The probe will also investigate some of Ceres' most intriguing mysteries, attempting to confirm the existence of water-vapor plumes and determine the nature of strange bright spots on it surface.
- Dawn will study Ceres from a series of ever-closer orbits: The altitudes of the latter three orbits are 4,400 km (2,700 mi) June 6-30, 1,450 km (900 mi) Aug 4-Oct 15 and 375 km (230 mi), Dec 8-May 9.
- Dawn will reside in the Survey orbit from June 6 - June 30, HAMO from Aug. 4 - Oct. 15 and LAMO from Dec. 8 through the end of the mission, currently pegged for June 30, 2016.
- The Dawn team members stress, that these orbit dates are tentative and could very well change. ##

## Dawn probe circles Ceres closer and closer, taking pictures

28 May, 2015 - [www.space.com/29514-nasa-dawn-ceres-craters-photo.html](http://www.space.com/29514-nasa-dawn-ceres-craters-photo.html)



A new photo from NASA's Dawn spacecraft shows the battered surface of the dwarf planet Ceres in unprecedented detail. Dawn captured the image on May 23, when the probe was just 3,200 miles (5,100 kilometers) from Ceres. The photo's resolution is about 1,600 feet (480 meters) per pixel, scientists said. The view shows numerous secondary craters, formed by the re-impact of debris strewn from larger impact sites. Smaller surface details like this are becoming visible with increasing clarity as Dawn spirals lower in its campaign to map Ceres. ##

## Dwarf Planet Ceres Revealed in Amazing Video

9 June, 2015 - <http://www.space.com/29603-dwarf-planet-ceres-video-nasa-dawn.html>

## Ceres Spots Continue to Mystify in Latest Dawn Images

22 June, 2015 - <http://www.jpl.nasa.gov/news/news.php?feature=4633>

The closer we get to Ceres, the more intriguing the distant dwarf planet becomes.

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- New Dawn spacecraft images of Ceres provide more clues about its **mysterious bright spots**
- They also reveal a **pyramid-shaped peak towering over a relatively flat landscape**.
- The surface of Ceres has revealed many interesting and unique features. For example, on Ceres, central pits in large craters are much more common than on icy moons in the outer solar system where craters have central pits,
- These and other features will help us understand the inner structure of Ceres not sensed directly.
- Dawn has been studying the dwarf planet in detail from its mapping orbit, which is Dawn has been studying the dwarf planet in detail from its mapping orbit, which is 4,400 km (2,700 m) above Ceres.
- A new view of its intriguing bright spots, located in a crater about 90 km (55 mi) across, shows even more small spots in the crater than were previously visible.
- At least eight spots can be seen next to the largest bright area. about 9 km (6 mi) wide. A highly reflective material is responsible for these spots – ice and salt are leading possibilities, but we do not know.
- Dawn's visible and infrared mapping spectrometer **allows us to identify specific minerals** present on Ceres by looking at how light is reflected.
- Each mineral reflects the range of visible and infrared-light wavelengths in a unique way. This signature helps scientists determine the components of Ceres.
- So, as the spacecraft continues to send back more images and data, scientists will learn more about the mystery bright spots.
- The latest images also show a mountain with steep slopes protruding from a relatively smooth area of Ceres' surface. The structure rises about 5 km (9.3 mi) above the surface.
- Ceres also has numerous craters of varying sizes, many with central peaks.
- There is ample evidence of past activity on the surface, including flows, landslides and collapsed structures. Ceres shows more remnants of activity than the protoplanet Vesta, which Dawn studied intensively for 14 months in 2011 and 2012.
- Dawn arrived at Ceres on March 6, 2015.
- Dawn will remain in its current altitude until June 30, continuing to take images and spectra of Ceres in orbits of about three days each. It then will move into its next orbit at an altitude of 1,450 km (900 mi) arriving in early August.
- Dawn is a project of the directorate's Discovery Program, managed by NASA's Marshall Space Flight Center in Huntsville, Alabama.
- UCLA is responsible for overall Dawn mission science.
- Orbital ATK Inc., in Dulles, Virginia, designed and built the spacecraft.
- The German Aerospace Center, Max Planck Institute for Solar System Research, Italian Space Agency and Italian National Astrophysical Institute are international partners on the mission team.
- For a complete list of mission participants, visit:
- <http://dawn.jpl.nasa.gov/mission>
- More information about Dawn is available at:  
<http://dawn.jpl.nasa.gov/>

## COMETS

### Scary times for Europe's comet-chaser Rosetta

[www.spacedaily.com/reports/Scary\\_times\\_for\\_Europes\\_comet-chaser\\_Rosetta\\_999.html](http://www.spacedaily.com/reports/Scary_times_for_Europes_comet-chaser_Rosetta_999.html)

3 April, 2015 – Europe's pioneering probe Rosetta battled breakdowns with navigation and communication with Earth after it ran into blasts of dust and gas from the comet it is tracking.

#### The plan and the monkeywrench

- Rosetta has had some “heart-stopping moments”



- The craft has been successfully recovered, but it will take time to resume normal scientific operations
- Rosetta won't be going so close (to the comet) again.
- It had been circling "67P/C-G" since last August, catching up with the wanderer after a 10-year, 6.5-billion-km (4-billion-mi) chase across space.
- Swooping close to Comet 67P/Churyumov-Gerasimenko, Rosetta experienced significant "difficulties."



Left: artist depiction – Right: the many faces of the comet

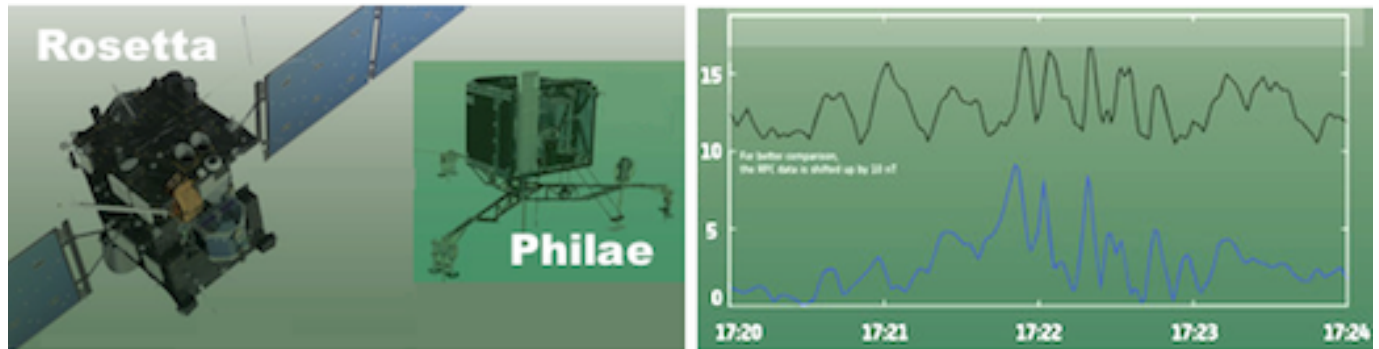
### The Plan and the “monkey wrench

- The mission seeks to unveil the secrets of comets, time capsules from the birth of the Solar System.
- The comet is getting closer to the Sun with every second, and the solar heat is warming its surface.
- This in turn is causing dust to be stripped away and gases to heat and blast out into space.
- This spectacular show, might be seen from Earth as a fiery "coma" when a comet passes close by.
- For Rosetta, though, the outpouring was a problem on an unexpected scale, as the orbiter raced to within 14 kilometres of the surface.
- Flying through dense, outflowing gas and dust exposed the spacecraft's solar panels, like outstretched wings, to drag.
- Another problem was that Rosetta is designed to navigate by locking on to the stars -- and its trackers mistook hundreds of pieces of comet debris for stars.
- As a result, the craft began to drift and its high-gain antenna, used to send and receive signals from ground stations on Earth, started to point away from home... and communications began to falter.
- The problems began on Saturday morning and lasted until Sunday night. On Sunday morning, we were losing communications with Rosetta. The signal fade bit by bit..
- Rosetta then automatically placed itself into safe mode, turning off all instruments to try to keep in touch with the distant Earth.
- The star trackers came back online when the probe was about 75 km (47 mi) from the comet" and the craft was able to find its position once more.
- By Monday, ground teams had brought Rosetta back to normal status.
- "The spacecraft is in perfect shape and did not suffer any damage and is now at a safer distance of 400 km from the comet, and will be brought back to within 100 km.
- Future flybys will have to be reassessed to take into account the dust and gas peril, likely to worsen as the comet heads towards perihelion, its closest point to the Sun.
- "Months of work planning the trajectories will have to be scrapped
- Rosetta's science programme -- scanning the comet with 11 instruments -- will need to be reviewed.
- On November 12, Rosetta sent down a fridge-sized robot lab, Philae, which carried out a 54-hour roster of experiments before its battery ran out of power.
- The lander is believed to be in the shadow of a cliff, preventing its solar panels from getting enough sunlight to power up.
- The mission hopes Philae will revive as 67/P gets closer to the Sun.
- Perihelion will be on August 13, when the comet will be 186 million km from the Sun. ##

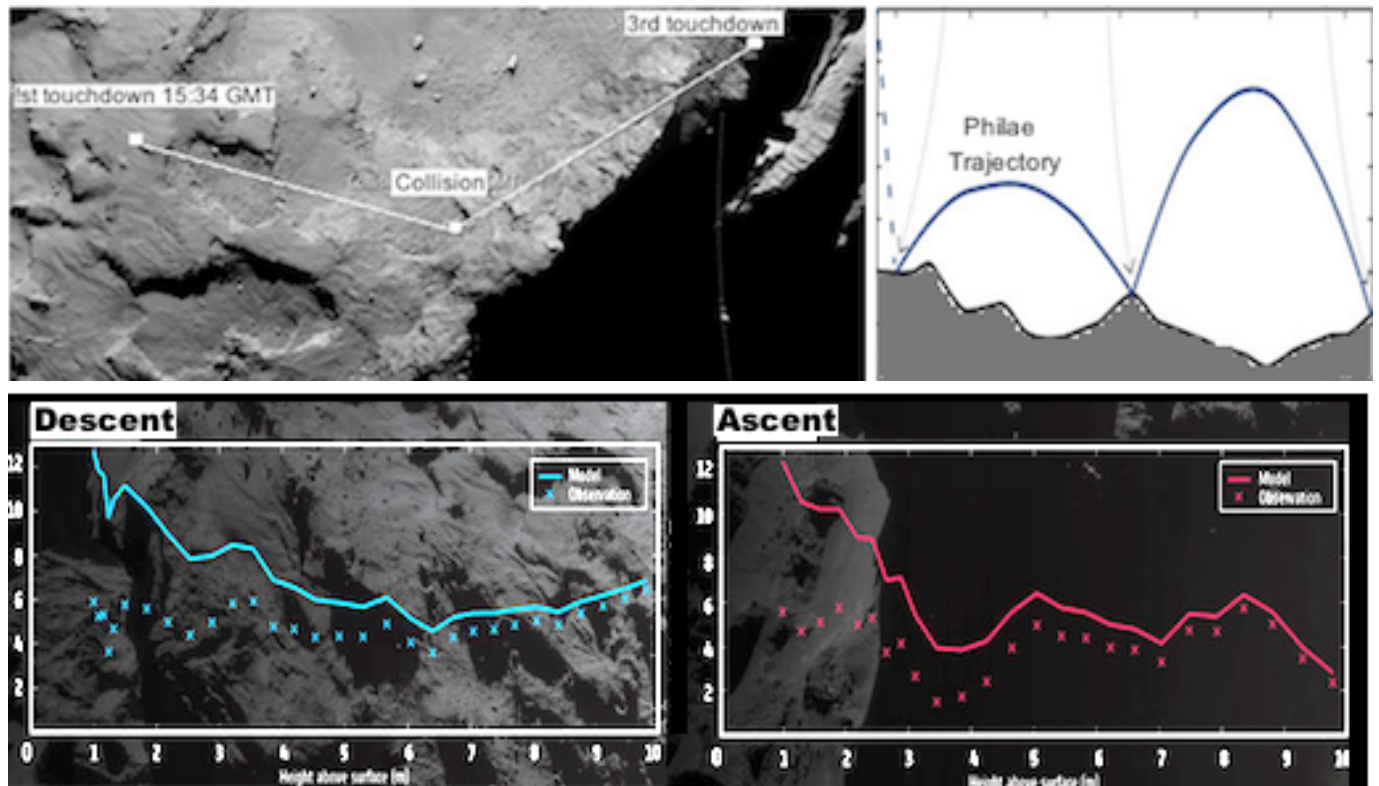
## Rosetta and Philae find Comet Not Magnetized

[www.esa.int/Our\\_Activities/Space\\_Science/Rosetta/Rosetta\\_and\\_Philae\\_find\\_comet\\_not\\_magnetised](http://www.esa.int/Our_Activities/Space_Science/Rosetta/Rosetta_and_Philae_find_comet_not_magnetised)

14 April, 2015 – Measurements made by Rosetta and Philae during the probe's multiple landings on Comet 67P/Churyumov–Gerasimenko show that the comet's nucleus is not magnetised.



- The properties of a comet can provide clues to the role that magnetic fields played in the formation of Solar System bodies almost 4.6 billion years ago.
- The infant Solar System was once nothing more than a swirling disc of gas and dust but, within a few million years, the Sun burst into life in the centre of this turbulent disc, with the leftover material going into forming the asteroids, comets, moons and planets.
- The dust contained **an appreciable fraction of iron, some of it in the form of magnetite.**
- Magnetic fields threading through the proto-planetary disc could have played an important role in moving material around as it started to clump together to form larger bodies.



- The dust contained **an appreciable fraction of iron, some of it in the form of magnetite.**
- Magnetic fields threading through the proto-planetary disc could have played an important role in moving material around as it started to clump together to form larger bodies.
- It is unclear how crucial magnetic fields were as building blocks grew, before gravity began to dominate as they grew to kilometres in scale.
- Bigger objects could also remain magnetised, influenced by proto-planetary disc magnetism.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

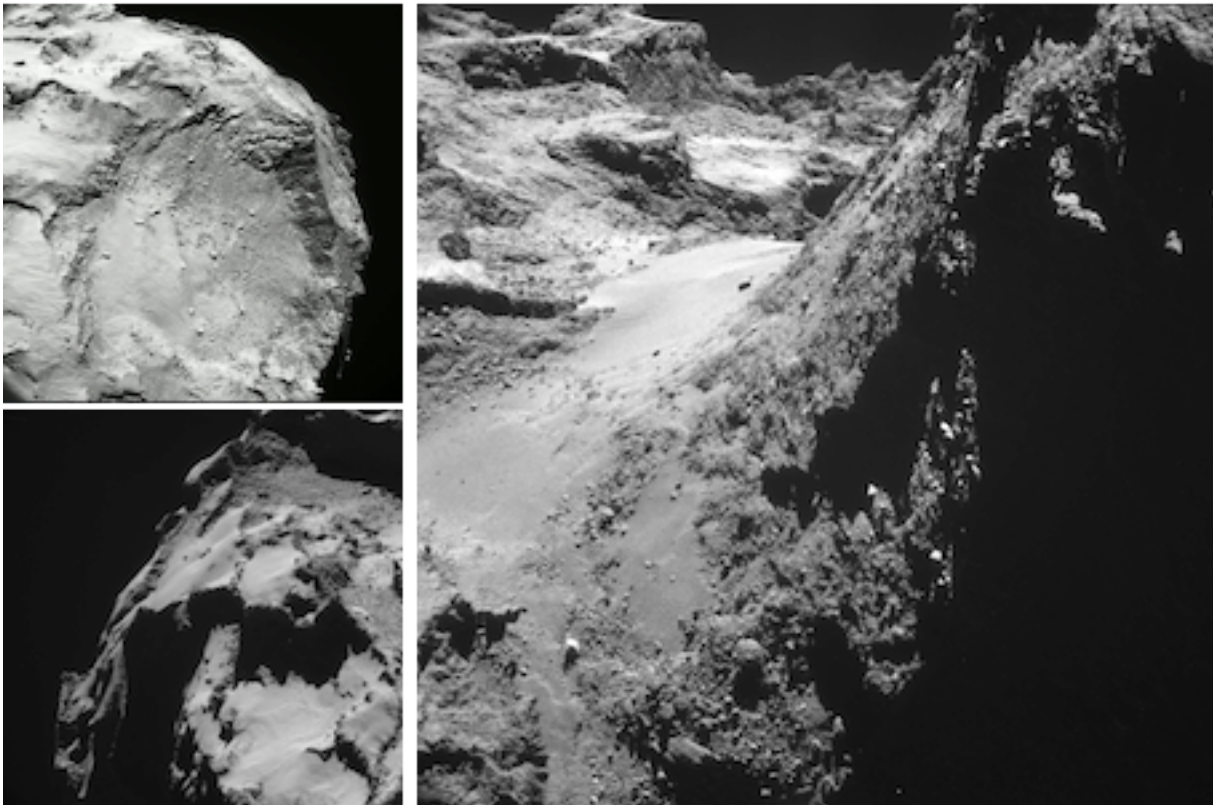
and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- AS comets contain pristine materials in the Solar System, they are evidence in investigating whether larger chunks could have remained magnetised.
- Detecting magnetic fields of comets has proven difficult in rapid flybys, far from comet nuclei.
- The proximity of the Rosetta orbiter to Comet 67P/Churyumov–Gerasimenko, measurements made much closer to and on the surface by its lander Philae, provide the first detailed investigation of the magnetic properties of a comet nucleus. ##

## Eerie Comet Landscape Revealed by Rosetta Spacecraft Photos

2-June, 2015 – [www.space.com/29541-erie-comet-landscape-photos.html](http://www.space.com/29541-erie-comet-landscape-photos.html)

- A deluge of newly released photos from the Rosetta mission reveals the haunting alien landscape on the surface of a comet as it orbits the sun.
- The European Space Agency (ESA) has released over 1,700 new images of the Comet 67P/Churyumov–Gerasimenko, taken by the Rosetta spacecraft during its closest approach.
- The two-lobe shape of 67P/Churyumov–Gerasimenko has drawn comparisons to a rubber duck (with a round head and larger body joined together by a narrow section).
- The images reveal a highly varied topological landscape on the surface of the comet. In one image, the cliffs of Hathor are visible. These cliffs stretch 900 m (2952 ft) high.
- Rosetta traveled to Comet 67P/Churyumov–Gerasimenko along with the Philae lander, which touched down on the comet's surface on Nov. 12, 2014. Philae bounced off the surface and came to rest in a shadowed region where its solar panels do not receive enough light to recharge the lander.
- The swarm of newly released photos was taken around the time that Philae made its historic leap onto the comet's surface.



## Ultraviolet Study Reveals Surprises in Comet Coma

[www.esa.int/Our\\_Activities/Space\\_Science/Rosetta/Ultraviolet\\_study\\_reveals\\_surprises\\_in\\_comet\\_coma](http://www.esa.int/Our_Activities/Space_Science/Rosetta/Ultraviolet_study_reveals_surprises_in_comet_coma)

2 June, 2015 – Rosetta's continued close study of Comet 67P/Churyumov–Gerasimenko has revealed an unexpected process at work, causing the rapid breakup of water and carbon dioxide molecules spewing from the comet's surface.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



- Since ESA's Rosetta mission arrived at the comet in August last year, it has been orbiting or flying past the comet at distances **from as far as several hundred kilometres down to as little as 8 km**.
- It has been collecting data on every aspect of the comet's environment with 11 science instruments.
- The Alice spectrograph provided by NASA, has been examining the chemical composition of the comet's atmosphere, or coma, at far-ultraviolet wavelengths, allowing scientists to detect some of the most abundant elements in the Universe such as hydrogen, oxygen, carbon and nitrogen.
- The spectrograph splits the comet's light into its various colours – its spectrum – from which scientists can identify the chemical composition of the coma gases.
- The team focused on the nature of 'plumes' of water and carbon dioxide gas erupting from the comet's surface, triggered by the warmth of the Sun.
- Emissions from hydrogen and oxygen atoms result from broken water molecules, and similarly carbon atoms from carbon dioxide molecules, close to the comet nucleus.
- The molecules seem to be broken up in a two-step process.
- First, an ultraviolet photon from the Sun hits a water molecule in the comet's coma and ionises it, knocking out an energetic electron. This electron then hits another water molecule in the coma, breaking it apart into two hydrogen atoms and one oxygen, and energising them in the process.
- These atoms then emit ultraviolet light that is detected at characteristic wavelengths by Alice.
- By comparison, from Earth or from Earth-orbiting space observatories such as the Hubble Space Telescope, the atomic constituents of comets can only be seen after their parent molecules, such as water and carbon dioxide, have been broken up by sunlight, hundreds to thousands of kilometres away from the nucleus of the comet. ##

## Rosetta's Lander Philae Wakes up from Hibernation

[www.esa.int/Our\\_Activities/Space\\_Science/Rosetta/Rosetta\\_s\\_lander\\_Philae\\_wakes\\_up\\_from\\_hibernation](http://www.esa.int/Our_Activities/Space_Science/Rosetta/Rosetta_s_lander_Philae_wakes_up_from_hibernation)  
[www.spacedaily.com/reports/Lander\\_makes\\_fresh\\_contact\\_from\\_comet\\_surface\\_agency\\_999.html](http://www.spacedaily.com/reports/Lander_makes_fresh_contact_from_comet_surface_agency_999.html)

14 June, 2015 – (1) Rosetta's lander Philae has woken up after seven months in hibernation on the surface of Comet 67P/Churyumov-Gerasimenko.



- The signals were received at ESA's European Space Operations Centre in Darmstadt on 13 June.
- More than 300 data packets have been analysed at the Lander Control, German Aerospace Center.
- Philae is doing very well and has an operating temperature of  $-35^{\circ}\text{C}$  and has 24 Watts available.
- For 85 seconds Philae "spoke" with its team on ground, via Rosetta, the first contact since November.
- The status data revealed that Philae must have been awake earlier, but not able to contact us earlier."
- Scientists are waiting for the next contact. There are more than 8000 data packets in Philae's mass memory which will give information on what happened to the lander in the past few days.
- Philae shut down on 15 November 2014 after being in operation on the comet for about 60 hours.
- Since 12 March 2015 the communication unit on Rosetta was turned on to listen out for the lander.

The Rosetta comet mission launched toward Comet 67P in 2004 and traveled 4 billion miles (6.4 billion kilometers) over 10 years to reach its destination. Rosetta arrived at the comet in August 2014 and is expected to continue studying 67P through December. ##



## a Mission Extended

23 June, 2015 – [www.esa.int/Our\\_Activities/Space\\_Science/Rosetta/Rosetta\\_mission\\_extended](http://www.esa.int/Our_Activities/Space_Science/Rosetta/Rosetta_mission_extended)

ESA confirmed that its Rosetta mission will be extended until the end of September 2016, and then most likely be landed on the surface of Comet 67P/Churyumov–Gerasimenko.

- Rosetta was launched in 2004 and arrived at the comet in August 2014, where it has been studying the nucleus and its environment as the comet moves along its 6.5-year orbit closer to the Sun.
- After a detailed survey, Rosetta deployed the Philae lander to the surface on 12 November.
- Philae fell into hibernation after 57 hours but recently awoke and made contact with Rosetta again.
- Rosetta's nominal mission was originally funded until the end of December 2015.A
- ESA's Science Programme Committee has approved extending the mission for another nine months.
- At that point, as the comet moves far away from the Sun again, there will no longer be enough solar power to run Rosetta's set of scientific instrumentation efficiently.
- Rosetta will monitor the decline in the comet's activity as it moves away from the Sun again, and is able to fly closer to the comet to continue collecting more unique data.
- By comparing detailed 'before and after' data, we'll have a much better understanding of how comets evolve during their lifetimes.
- Comet 67P/Churyumov–Gerasimenko will make its closest approach to the Sun on 13 August .
- Rosetta has been watching its activity increase over the last year. Continuing its study in the year after that closest approach will give a fuller picture of how comet activity waxes and wane.
- The extra observations will also provide additional context for complementary Earth-based observations of the comet.
- At present, the comet is close to line-of-sight to the Sun, making ground-based observations difficult.
- As the activity diminishes post-perihelion, it should be possible to move the orbiter much closer to the comet nucleus again, for a detailed survey of changes in its properties during its brief 'summer'.
- There may also be an opportunity to make a definitive visual identification of the Philae lander.
- Images taken from 10 km or less after perihelion could provide the most compelling confirmation.
- The team will use experience gained in operating Rosetta to carry out some new, potentially slightly riskier investigations, including flights across the night-side of the comet to observe the plasma, dust, and gas interactions in this region, and to collect dust samples ejected close to the nucleus.
- As the comet recedes from the Sun, the solar-powered spacecraft will no longer receive enough sunlight to operate efficiently and safely
- Rosetta and the comet will again be close to the Sun as seen from the Earth in October 2016, making operations difficult by then.
- With Rosetta's propellant largely depleted by that time, it makes little sense to place the spacecraft in hibernation again.
- The most logical way to end the mission is to set Rosetta down on the comet's surface.
- There is still a lot to do to confirm that this end-of-mission scenario is possible. A lot depends on the status of the spacecraft after perihelion and how well it is performing close to the comet
- Later we will have to try and determine where on the surface we can have a touchdown.
- The spacecraft would be commanded to spiral down to the comet over a period of about three months.
- Science operations would continue throughout this period and be feasible up to very close to the end of mission, allowing Rosetta's instruments to gather unique data at unprecedentedly close distances.
- Once the orbiter lands on the surface, it is highly unlikely to be able to continue operations and relay data back to Earth, ending one of the most successful space exploration missions of all time. ##

## Charged Particles Play Surprising Role in Comet's Eruptions

16 June, 2015 – [www.space.com/29672-rosetta-comet-eruptions-surprising-discovery.html](http://www.space.com/29672-rosetta-comet-eruptions-surprising-discovery.html)

Electrons cause the rapid breakup of water and carbon dioxide molecules erupting from the surface of comet 67P/Churyumov–Gerasimenko, new findings reveal.

- The discovery made using NASA's Alice instrument aboard the European Space Agency's Rosetta spacecraft was surprising to scientists, who had previously thought that light particles, or photons, from the sun caused these eruptions.
- The discovery is quite unexpected, and will fundamentally transform our knowledge of comets.
- It shows the value of going to comets to observe them up close, since this discovery simply could not have been made from Earth or Earth orbit with any existing or planned observatory,
- As a comet travels closer to the sun in its orbit around the star, heat melts the rock and ice to create the familiar tail that streams from its nucleus.
- The heat also causes plumes of water and carbon dioxide gas to erupt from the surface of the comet.
- Since last August, Rosetta has orbited within 160 km (100 mi) of comet 67P, allowing the Alice instrument to study the comet and its plumes in ultraviolet light.
- To better understand these plumes, the team studied the emission of hydrogen and oxygen atoms that formed as water molecules broke, as well as carbon atoms from destroyed carbon dioxide molecules.
- They found that the molecules were broken up in a two-step process.
- First, an ultraviolet photon from the sun hits a water molecule in the comet's coma, or atmosphere, knocking an electron free.
- The electron then hits another water molecule in the coma, breaking it completely apart into two hydrogen atoms and one oxygen atom, energizing them in the process.
- The energized atoms emit ultraviolet light that Alice detects.
- Sometimes, the electron collides with a carbon dioxide molecule, resulting in the breakup into carbon atoms and resulting carbon emission.
- Analysis of the relative intensities of observed atomic emissions allows us to determine that we are directly observing the 'parent' molecules that are being broken up by electrons in the immediate vicinity, about 1 km, of the comet's nucleus where they are being produced.
- The team compared the breakup of the molecules to the process proposed for the plume spotted on Europa. However, the electrons of the comet are produced by solar photons, whereas the electrons on Europa come from Jupiter's magnetic field.
- Alice's far-ultraviolet spectrum allowed scientists to trace the structure and location of the plumes on comet 67P, surpassing what can be done from Earth or Earth orbit.
- Observatories such as the Hubble Space Telescope can only spot the atomic constituents of comets after their parent molecule — the water or carbon dioxide — has already been broken apart.
- These early results demonstrate how important it is to study a comet at different wavelengths and with different techniques, in order to probe various aspects of the comet's environment
- "We're actively watching how the comet evolves as it moves closer to the sun along its orbit towards perihelion [point nearest to the sun] in August, seeing how the plumes become more active due to solar heating and studying the effects of the comet's interaction with the solar wind." ##

## Rosetta Probe Detects Water Ice on Comet's Surface

[www.esa.int/Our\\_Activities/Space\\_Science/Rosetta/Exposed\\_water\\_ice\\_detected\\_on\\_comet\\_s\\_surface](http://www.esa.int/Our_Activities/Space_Science/Rosetta/Exposed_water_ice_detected_on_comet_s_surface)

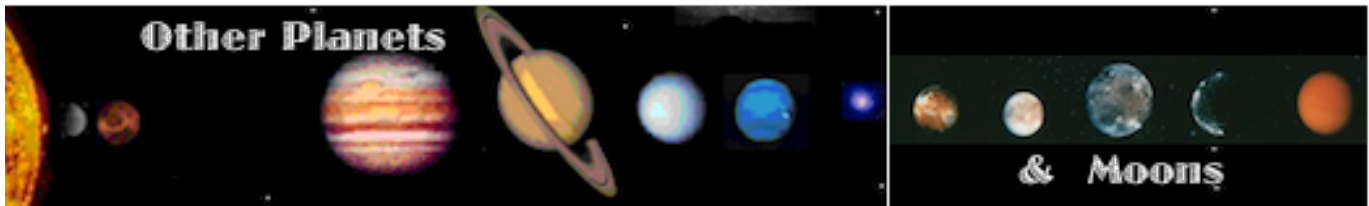


Ice on Comet 67P/Churyumov-Gerasimenko

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

24 June, 2015 – The high-resolution science camera on ESA's Rosetta probe, has identified a hundred plus patches of water ice a few metres in size on the surface of comet 67P/Churyumov-Gerasimenko.

- Rosetta arrived at the comet in August 2014 at a distance of about 100 km and eventually orbited the comet at 10 km or less, allowing high-resolution images of the surface to be acquired.
- A new study focuses on an analysis of bright patches of exposed ice on the comet's surface.
- Based on observations of gas emerging from comets, they are known to be rich in ices.
- As they move closer to the Sun in their orbits, their surfaces are warmed and the ices sublime into gas, which streams away from the nucleus, dragging along dust particles to form coma and tails.
- Some of the comet's dust also remains on the surface as the ice below sublimates, or falls back on to the nucleus, coating it with a thin layer of dusty material with very little ice directly exposed.
- These processes help to explain why Comet 67P/Churyumov-Gerasimenko and other comets seen in previous flyby missions are so dark.
- Despite this, Rosetta's suite of instruments has already detected a variety of gases, including water vapour, carbon dioxide and carbon monoxide, thought to originate from frozen sub-surface reservoirs.
- Images taken with Rosetta's OSIRIS narrow-angle camera last September, have identified 120 regions on the surface of the Comet that are up to ten times brighter than the average surface brightness.
- Some of these bright features are found in clusters, while others appear isolated, and when observed at high resolution, many of them appear to be boulders displaying bright patches on their surfaces.
- The clusters of bright features, comprising a few tens of metre-sized boulders spread over several tens of metres, are typically found in debris fields at the base of cliffs, most likely the result of recent erosion or collapse of the cliff wall revealing fresher material from below the dust-covered surface.
- By contrast, some of the isolated bright objects are found in regions without any apparent relation to the surrounding terrain. They may be objects lifted up from elsewhere on the comet during a period of cometary activity, but with insufficient velocity to escape the gravitational pull of the comet completely.
- In all cases, the bright patches are found in areas that receive relatively little solar energy, such as in the shadow of a cliff, with no significant changes observed between images taken over a month.
- Furthermore, they were found to be bluer in colour at visible wavelengths compared with the redder background, consistent with an icy component.
- Water ice is the most plausible explanation for the occurrence and properties of these features.
- "At the time of our observations, the comet was far enough from the Sun such that the rate at which water ice would sublime would have been less than 1 mm per hour of incident solar energy.
- If carbon dioxide or carbon monoxide ice had been exposed, it would have rapidly sublimated when illuminated by the same amount of sunlight.
- The team also turned to laboratory experiments that tested the behaviour of water ice mixed with different minerals under simulated solar illumination in order to gain more insights into the process.
- They found that after a few hours of sublimation, a dark dust mantle a few millimetres thick was formed. In some places this acted to completely conceal any visible traces of the ice below.
- Occasionally larger dust grains or chunks would lift from the surface exposing patches of water ice.
- A 1 mm thick layer of dark dust is sufficient to hide the layers below from optical instruments.
- The relatively homogeneous dark surface of the nucleus of Comet 67P/Churyumov-Gerasimenko, only punctuated by some metre-scale bright dots, can be explained by the presence of a thin dust mantle composed of refractory mineral and organic matter, with the bright spots corresponding to areas from which the dust mantle was removed, revealing a water-ice-rich subsurface below."
- The team also speculates about the formation timing of the icy patches. They may have formed at the time of the last closest approach of the comet to the Sun, 6.5 years ago, icy blocks ejected into permanently shadowed regions, preserved for several years below the temperature needed for sublimation.
- Even at relatively large distances from the Sun, carbon dioxide and monoxide driven-activity could eject the blocks. It is assumed that the temperature was not yet high enough for water sublimation, so that water-ice-rich components outlive any exposed carbon dioxide or carbon monoxide ice.
- As the comet approaches perihelion, increases in solar illumination onto the bright patch shadow should cause changes in their appearance. We expect to see new, even larger regions of exposed ice.
- "Combining OSIRIS observations made pre- and post-perihelion with other instruments will provide valuable insight into what drives the formation and evolution of such regions." ##



[The articles below have been summarized by the editor. For the full text, see the links cited.]

## MERCURY

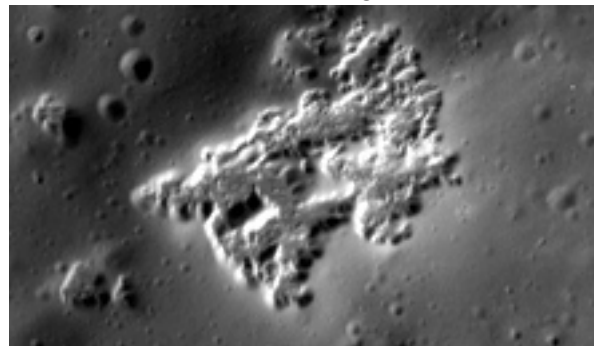
### Strange 'Hollows' on Mercury Revealed by Messenger as End Nears

2 April, 2015 - [www.space.com/28992-mercury-strange-hollows-messenger-photos.html](http://www.space.com/28992-mercury-strange-hollows-messenger-photos.html)

<http://i.space.com/images/i/000/008/584/i300/messenger-mercury-orbiter-110309d-02.jpg?1299842910>

Mercury, the barren planet closest to the Sun, may seem like a dead world, but new images by a NASA probe nearing the end of its life reveal that it may still be undergoing geological activity.

- New images from the Messenger Mercury Orbiter show that Mercury has strange features, "hollows" – irregularly shaped, flat-floored depressions a few tens of meters deep, a kilometer wide at most.
- That finding suggests that Mercury may have lost some of its lighter elements, such as sodium and potassium — a phenomenon that may still be happening today.



This high-resolution view of Mercury shows hollows — irregularly shaped, flat-floored depressions — on the southwestern peak ring of the Scarlatti basin. Although there are a number of small impact craters surrounding the hollows, there are few, if any, within the hollows themselves, indicating that they are much younger than the rest of the planet's surface.

- Hollows are a surprise in terms of the geological processes that shape the surface at small scales.
- When NASA's Mariner 10 flew by Mercury three times in the mid-1970s, it spotted what was described as "certain odd, bright patches" within the impact craters.
- It wasn't until 2011, when MESSENGER entered orbit and began to capture higher-resolution images, that the bright areas were revealed as shallow, irregularly shaped depressions on the surface.
- Hollows are relatively small landforms, shallow surface features that stretch at most 1 km (0.6 mi).
- This small size implies a relatively young age, as cratering would have eroded them away over time.
- The hollows do not contain many, if any, impacts within them — another characteristic that suggests that they are fairly young.
- Finally, the hollows' sharp edges also likely indicate these features were made relatively recently.
- They have a crisp, fresh appearance, and are probably younger than a few tens of millions of years.
- Some hollows are probably forming today – ongoing geological activity modifying the surface
- While the Moon lacks similar features, the southern polar cap of Mars and some of the icy satellites in the outer solar system have shapes that resemble the hollows.
  - Water ices on Mars and distant moons mix with non-ice material – dirt and rock.
  - When the sun heats these regions, the ice sublimates — changing directly from ice to gas.
  - Voids grow within the features, and the remaining dirt/rock mixture collapses, creating pits.



- Unlike Mars and the outer moons, the bulk of Mercury's surface lacks ice. But that doesn't mean the process is completely invalid.
- It appears that there is something in the rocks that can't stand up to the punishing environment on Mercury's surface and, as a result, is lost in a sublimation-like process
- Mercury suffers very high temperatures – 427 °C (801 °F),
- It is also bombarded by energetic ions from the solar wind, more densely than on any other planet.
- The weak magnetic field offers scant protection from charged particles accelerating to even higher temperatures before slamming into the surface.
- Finally, Mercury's proximity to the Sun means it gets hit by more micrometeorites, often at higher speeds than those that hit the Moon, creating grueling conditions on the planet.
- MESSENGER has also provided clues to the identity of the elements involved in their formation.
- Instruments on the spacecraft reveal that Mercury has more volatiles (elements with low boiling points — such as potassium, chlorine and sulfur.
- Their presence surprised scientists, who had thought these elements would be rare.
- Based on the abundances that were measured, it is likely that it is **a sulfur compound** that is being destroyed and lost to space in the locations where hollows are forming.

### The incredible shrinking planet

- Following its 2004 launch, MESSENGER became the first probe to enter orbit around Mercury, in 2011.
- On its 2nd extended mission, it slowly maneuvered closer to the planet; to only 14.9 km (9.3 mi) above the surface. This lower altitude allowed for more detailed measurements of Mercury's features.
- MESSENGER also identified features known as "scarps," smaller than those previously spotted.
- As Mercury's core cools, its crust contracts. Over the past few billion years, its diameter has decreased by several kilometers.
- As a result of contraction, one section of crust is thrust up/over a block nearby, creating long scarps.
- Most of the scarps identified over the course of the mission are hundreds of kilometers long.
- High-resolution images from the low-altitude campaign reveal several scarps more than an order of magnitude smaller than those previously spotted, likely very young, and may even be forming today.
- The campaign also took close-up images of the only water ice known to exist on Mercury in frozen puddles found in permanently shadowed regions near the planet's poles.
- Like the hollows, the ice has well-defined edges with few traces of small, young impact craters = indicating their youth.
- The water stored in the polar ice deposits was most likely carried to Mercury by impacts of comets and volatile-rich asteroids, similarly to how water is thought to have arrived on Earth.
- Finally, MESSENGER's closer orbit allowed detailed mapping of the planet with its X-ray spectrometer, which determined the abundances of key rock-forming elements and allowed the surface elemental composition of Mercury to be mapped in detail.

### Planet Mercury: Simple Facts, Tough Quiz

- The closest planet to the sun is also an elusive world, revealing itself in our night sky only fleetingly..
- The mission ended as MESSENGER was deliberately crashed into the surface.
- The MESSENGER team will continue to work together for another year, reviewing the newest measurements, as well as older measurements, and archiving the final data sets.

### A Great Mission

- MESSENGER has survived the severe thermal and radiation hazards of the inner solar system, including strong heating by Mercury's dayside surface and direct impact by coronal mass ejections and other energetic solar events. MESSENGER has been a reliable source of exciting new information.
- The MESSENGER team will work together for another year, reviewing the newest measurements, as well as older measurements, and archiving the final data sets.
- Over the course of its lifetime, the spacecraft has changed the way humans view the planet closest to the sun. Mercury turned out to be stranger than anyone would have guessed.
- It looks roughly like the Moon, but MESSENGER has shown that Mercury is vastly different from the Moon in just about every way. ##

## New explanation for Mercury's dark surface

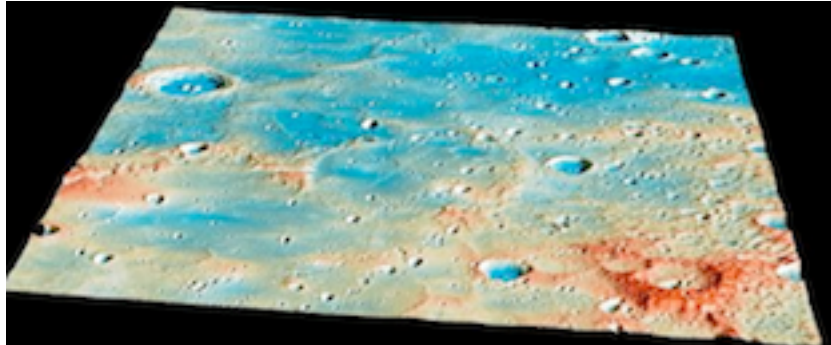
5 April, 2015 – [www.spacedaily.com/reports/New\\_explanation\\_for\\_Mercurys\\_dark\\_surface\\_999.html](http://www.spacedaily.com/reports/New_explanation_for_Mercurys_dark_surface_999.html)

The surface of Mercury appears dark and unreflective, an observation that has long puzzled planetary scientists due to the planet's very low surface abundance of iron (less than 2%).

- Iron is an important darkening material in airless bodies like the Moon and asteroids.
- While the intense space weathering environment on Mercury, which efficiently converts the small amount of available iron into submicroscopic metallic iron, contributes to its dark surface, this effect is not sufficient to explain observations of Mercury's appearance.
- Researchers have long speculated that a "mystery darkening agent" must be a contributor.
- In a Nature Geoscience study a team of researchers investigate, whether **carbon**, delivered by comets and/or comet dust, could be this elusive mystery darkening agent.
- The study implicates carbon as a "stealth" darkening agent, difficult to detect with available remote sensing methods.
- "Mercury is effectively painted black by the constant influx of carbon-rich micrometeorites."
- Numerical calculations to assess impact delivery of carbon on Mercury found that micrometeorites, mostly derived from carbon-enriched comets, would deliver enough carbon to affect observations of Mercury's surface.
- These micrometeorites' relatively low impact velocities allow most impacting material to be retained, resulting in surface carbon abundances near 3 to 6 percent.
- Hypervelocity impact experiments at the Ames Vertical Gun Range also tested whether carbon could be effectively entrained within glassy, impact-generated melt products, resulting in darker spectral signatures.
- The results were consistent with remote sensing observations of Mercury by the MESSENGER mission, further suggesting an important role for carbon at the surface of Mercury.
- Without samples from Mercury, planetary scientists rely on spectral modeling of Mercury's surface to interpret its composition and geologic history.
- Understanding the role of micrometeorites in delivering dark material to Mercury provides new ways of interpreting observations of the planet.
- Additionally, the team is now working on how micrometeorites may have delivered other materials of interest to Mercury, including water. ##

## MESSENGER is dead – Long live its Mercury Imagery (VIDEO)

27 April, 2015 – [www.space.com/29281-messenger-spacecraft-mercury-crash.html](http://www.space.com/29281-messenger-spacecraft-mercury-crash.html)



The region of Mercury where NASA's MESSENGER spacecraft crashed April 30, 2015. This image was taken by MESSENGER during the course of its work at Mercury and so does not show the resulting crater. Higher-elevation regions are colored red in this image, while lower areas are blue.

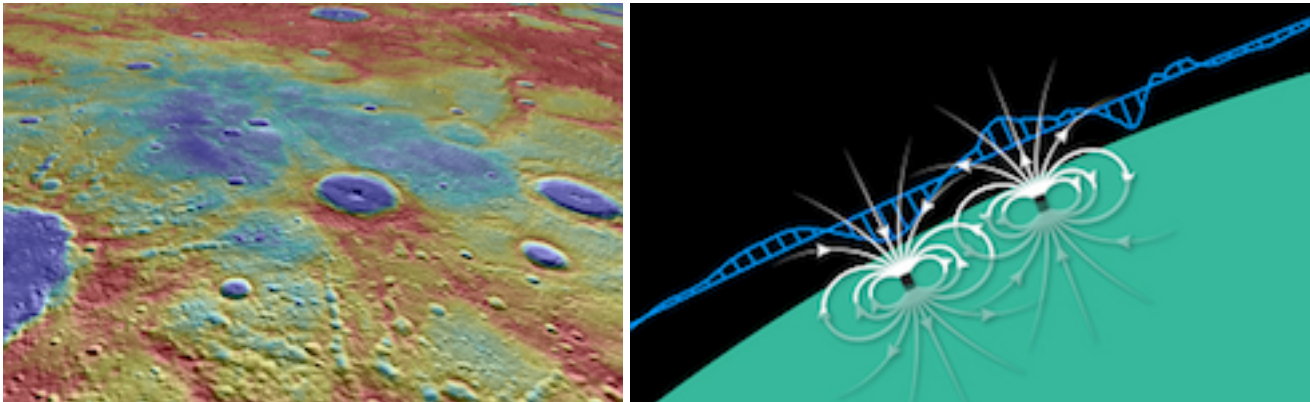
[www.space.com/29244-messenger-is-dead-long-live-its-mercury-imagery-video.html](http://www.space.com/29244-messenger-is-dead-long-live-its-mercury-imagery-video.html)

27 April, 2015 – Relive 7 glorious years of exploration with this animation/actual imagery retrospective. Completely drained of fuel, the probe will slam into Mercury's surface at over 8,750 miles per hour producing a crater about 50ft (16m) in diameter. ##

## Mercury's Magnetism May Have Once Rivalled Earth's

7 May, 2015 – [www.space.com/29340-mercury-ancient-magnetic-field.html](http://www.space.com/29340-mercury-ancient-magnetic-field.html)

The magnetic field of Mercury is 4 billion years old according to data from the MESSENGER spacecraft.



**Left:** This MESSENGER image shows a view of Mercury's Suisei Planitia region (the blue colors), where MESSENGER detected crustal magnetic signals.

**Right:** This diagram shows magnetic field lines (in white) from magnetized rocks in the crust of Mercury. The phenomenon was detected by an instrument on NASA's MESSENGER spacecraft during close orbits of Mercury.

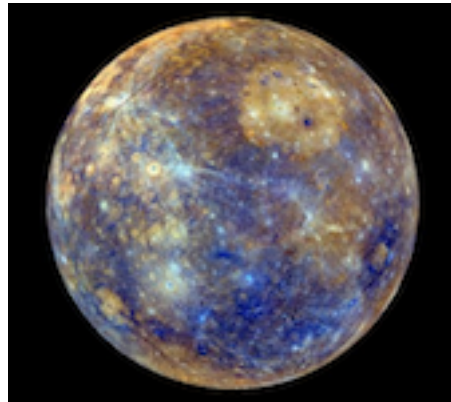
- Mercury has a magnetic field for billions of years, that may have once been as strong as Earth's.
- The discovery helps whittle down scenarios for how Mercury has evolved over time, scientists added.
- Mercury is the solar system's smallest and innermost planet – an enigmatic world for years.
- Until MESSENGER became the first probe to orbit the planet, in 2011, the only other visits Mercury received were the flybys made by NASA's Mariner 10 probe four decades ago. MESSENGER ended its mission on April 30 by crashing into Mercury's surface.
- Mariner 10 had revealed that Mercury possessed a magnetic field similar to Earth's, albeit one that is about 100 times weaker. The motion of liquid metal deep inside Mercury's core generates the planet's magnetic field. Mercury is the only rocky planet in the solar system besides Earth with such a magnetic field.
- This means Mercury's core has to be at least partially liquid, This was a surprise at first, because Mercury is very small, so you would expect it to cool quickly after it formed and be completely solid.
- Scientists later realized if there was a little bit of nonmetallic stuff in Mercury's core, that'd lower its freezing point and make it hard to be completely solid."
- This new finding regarding the magnetism of Mercury comes from MESSENGER. Launched in 2004, MESSENGER was in space for more than a decade and orbited Mercury for four years, yielding troves of data about the enigmatic world.
- Once out of fuel, it crashed into Mercury's surface, gouging a crater about 16 m (52 ft) wide.
- The mission was originally planned to last one year, but it lasted four.
- Researchers analyzed magnetic data collected by MESSENGER in the 2014 and 2015, when the craft flew incredibly close to the planet's surface, at altitudes as low as 1k km (9 mi). In contrast, the lowest that MESSENGER flew in previous years was between 200–400 km (125–250 mi).
- Signals detected were really small, and very hard to measure..
- Scientists detected magnetized rocks in a part of Mercury's crust that, due to the presence of many craters from cosmic impacts, appears to be quite ancient.
- Researchers suggest the rocks were once magnetized by the planet's magnetic field, and based on the age and amount of the magnetized rocks, as well as how strongly they were magnetized, the investigators deduced that Mercury's magnetic field has persisted for 3.8 billion years.
- The strength of Mercury's magnetic field may have ranged anywhere from its strength today to about 100 times stronger, comparable to the strength of the magnetic field at Earth's surface today, ##

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and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

## Messenger's Iridescent Mercury

15 June, 2015 – [www.esa.int/spaceinimages/Images/2015/06/Messenger\\_s\\_iridescent\\_Mercury](http://www.esa.int/spaceinimages/Images/2015/06/Messenger_s_iridescent_Mercury)



Full size image:

[www.esa.int/var/esa/storage/images/esa\\_multimedia/images/2015/06/messenger\\_s\\_iridescent\\_mercury/15445906-1-eng-GB/Messenger\\_s\\_iridescent\\_Mercury\\_node\\_full\\_image\\_2.jpg](http://www.esa.int/var/esa/storage/images/esa_multimedia/images/2015/06/messenger_s_iridescent_mercury/15445906-1-eng-GB/Messenger_s_iridescent_Mercury_node_full_image_2.jpg)

To the human eye, Mercury may resemble a dull, grey orb but this enhanced color image from NASA's Messenger probe, tells a completely different story. Swathes of iridescent blue, sandy-coloured plains and delicate strands of greyish white, create an ethereal and colourful view of Mercury.

- These contrasting colours have been chosen to emphasise the differences in the composition of the landscape across the planet.
- The darker regions exhibit **low-reflectance material**, particularly for light at redder wavelengths. As a result, these regions take on a bluer cast.
- The criss-crossing streaks across the disc of the planet show up in shades of light blue, grey and white. These regions take on a **light blue hue** for a different reason: their **youthfulness**. As material is exposed to the harsh space environment around Mercury it darkens, but these pale 'rays' are formed from material excavated from beneath the planet's surface and sent flying during comparatively recent impacts. For this reason, they have retained their youthful glow.
- The **yellowish, tan-coloured regions** are "intermediate terrain". Mercury also hosts brighter and smoother terrain known as **high-reflectance red plains**. One example can be seen towards the upper right, where there is a prominent patch that is roughly circular. This is **the Caloris basin**, an impact crater thought to have been created by an asteroid collision during the Solar System's early days.
- On 30 April this year, Messenger's four-year stint in orbit around Mercury ended when the probe ploughed into the surface. Messenger was launched in 2004 and in 2011 became the first spacecraft ever to orbit Mercury. It ended up exceeding its planned mission timeline by three years, by which time the spacecraft had completely depleted its fuel. The last of the fuel was used to position it within the gravitational pull of Mercury and the Sun, so it could delay as long as possible its inevitable plummet towards the surface – while continuing to beam back images – and go out with a bang.
- The investigation of mysterious Mercury will be continued by ESA/JAXA's BepiColombo, due for launch in 2017. This mission comprises two orbiters, ESA's **Mercury Planetary Orbiter** and (Japan's) JAXA's **Mercury Magnetospheric Orbiter**, which will reach Mercury together in 2024. BepiColombo aims to gain an in-depth view of our Solar System's least-explored terrestrial planet.  
BepiColombo: <http://sci.esa.int/bepicolombo/>

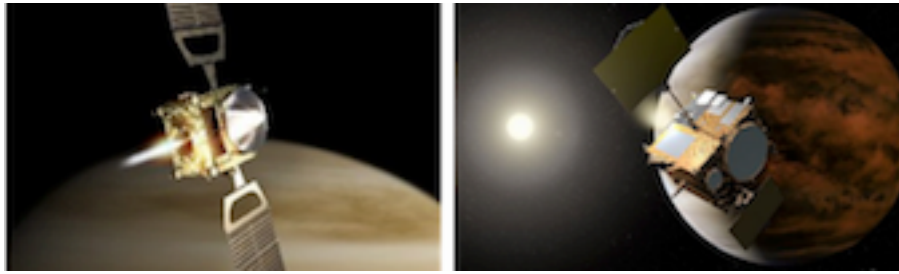
## VENUS

### Japanese Spacecraft to Attempt Venus Comeback in December

6 April, 2015 – [www.space.com/29017-japan-venus-spacecraft-akatsuki-second-chance.html](http://www.space.com/29017-japan-venus-spacecraft-akatsuki-second-chance.html)  
A Japanese spacecraft will get a 2nd chance to orbit Venus in December, five years after its first try.

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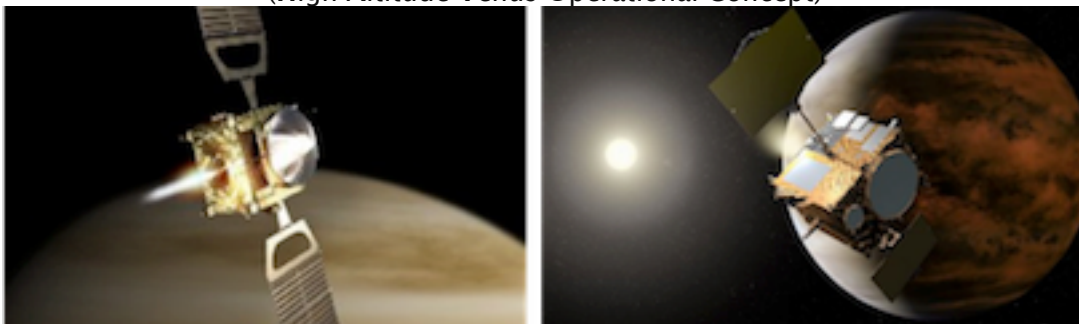




- The Akatsuki Venus probe was supposed to begin circling Earth's hellishly hot sister planet in December 2010, but the craft's main engine failed during the crucial orbital-insertion burn.
- Akatsuki has been orbiting the Sun ever since, waiting for another shot at Venus.
- Japan Aerospace Exploration Agency (JAXA) has pivvcked a date for the comeback attempt{: Dec. 7.
- Akatsuki's main engine is dead, it will try to achieve orbit with its smaller attitude-control thrusters,
- If the maneuver works, Akatsuki will slip into a **highly elliptical orbit** that completes one lap around Venus every 8–9 days. (The original mission plan called for a 30-hour orbital period.)
- Akatsuki, "dawn" in Japanese, will then study Venus' atmosphere with a variety of instruments, gathering **data about the planet's clouds, air circulation patterns** and other characteristics.
- Flying further away from Venus, c. 60,520 km (c.37,600 mi), Akatsuki will continuously observe Venus as a whole to understand its **clouds, deep atmosphere and surface conditions**,
- When flying closer to Venus, the orbiter will conduct close-up observations to **clarify cloud convection, the distribution of minute undulatory motions and their changes**.
- The \$300 million Akatsuki probe launched in May 2010 on a mission to help researchers better understand how Venus, once similar to Earth, ended up so hot and seemingly inhospitable to life.
- Akatsuki blasted off on the same rocket as JAXA's IKAROS (Interplanetary Kite-craft Accelerated by Radiation Of the Sun) spacecraft, the first probe ever to travel through deep space using a solar sail.
- Akatsuki was Japan's 2nd attempt to explore another planet with a robotic space probe.
- Japan's first interplanetary probe, the Nozomi Mars orbiter, also experienced problems after in 1998.
- A valve malfunction caused a significant amount of Nozomi's fuel to be lost, scuttling a planned 1999 Mars arrival. JAXA has tried to put Nozomi into orbit around Mars in December 2003 but failed. ##

## Project HAVOC: NASA Concept Could Explore Venus with Airships (Gallery)

20 April, 2015 – [www.space.com/29141-venus-airship-havoc-nasa-concept-gallery.html](http://www.space.com/29141-venus-airship-havoc-nasa-concept-gallery.html)  
(High Altitude Venus Operational Concept)

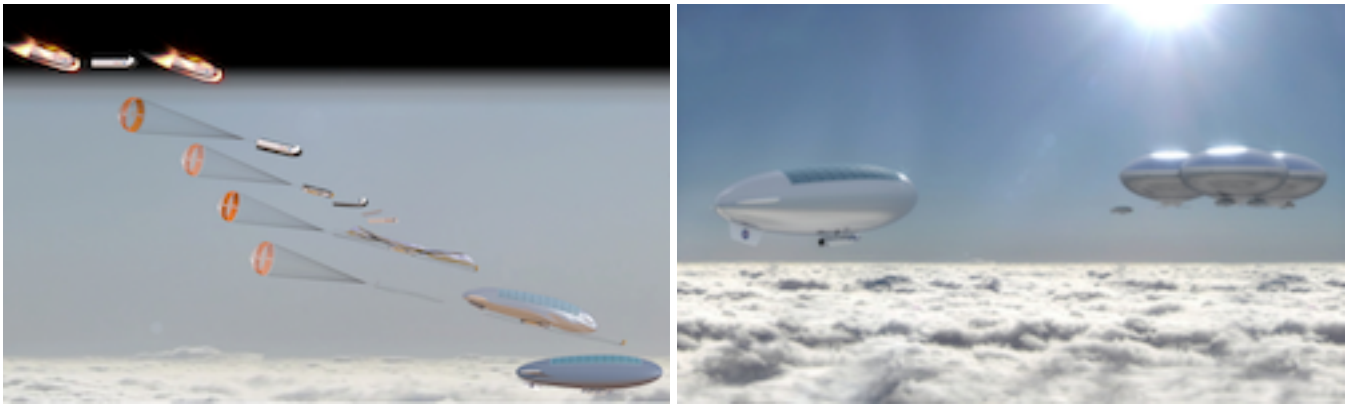


**L:** Helium-filled airships cruising through Venus skies **Right:** ascent vehicle climbing to Venus orbit.



**Left:** Side view of a robotic HAVOC airship, which would be considerably smaller than the manned version 31 m (102 ft) long versus 129 m (423 ft) long and lack the habitat and ascent vehicle.

**Right: Venus Ascent Module and Rocket**



HAVOC airship entering Venus' atmosphere | Artist's concept of a Venus cloud city

**Editor:** for our own concept of "Aerostat Xities over Venus" (1992) see

[http://www.moonsociety.org/publications/mmm\\_papers/venus\\_rehabpaper.htm#aerostat](http://www.moonsociety.org/publications/mmm_papers/venus_rehabpaper.htm#aerostat) ##

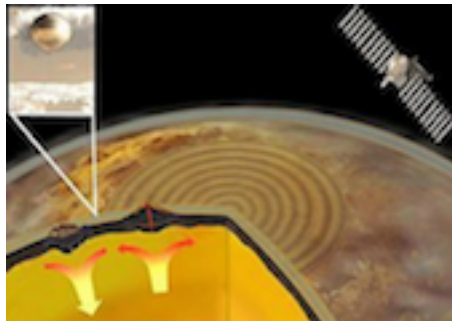
## Can sound help us detect 'earthquakes' on Venus?

[www.spacedaily.com/reports/Can\\_sound\\_help\\_us\\_detect\\_earthquakes\\_on\\_Venus\\_999.html](http://www.spacedaily.com/reports/Can_sound_help_us_detect_earthquakes_on_Venus_999.html)

24 April, 2015 – Detecting an "earthquake" on Venus would seem to be an impossible task.

Venus' surface is a hostile zone of crushing pressure and scorching temperatures--about 468 °C (874 °F), enough to melt lead and destroy any normal instruments used to gauge seismic activity.

- But conditions in Venus' atmosphere are much more hospitable (the higher up you are), and it is here that researchers hope to deploy an array of balloons or satellites that could detect Venusian seismic activity--using sound. [See article just above.]
- These kinds of low frequency or infrasonic sound waves, much too low to be audible, are already measured on Earth. The rumbling or "hum" can be generated by sources as diverse as volcanoes, earthquakes, ocean storms and meteor air blasts.
- In recent years, infrasonic observations have undergone a renaissance as a relatively inexpensive way to monitor atmospheric nuclear weapons tests.
- But last year, a team of experts convened by the Keck Institute for Space Studies began thinking of ways to use infrasonic observations to get a better look at the geological dynamics of Venus.
- At about 50–60 km (80–96 mi) above Venus' surface, temperature and pressure conditions are much more like those on Earth, albeit with a denser atmosphere.
- This dense atmosphere helps translate any seismic waves into infrasonic waves that can be detected with instruments floating above the planet's surface.
- Infrasonic waves can be "felt" as either fluctuations in pressure, or as light emissions called airglow, or electron disruptions in Venus' upper atmosphere.



Seismic waves radiating from a Venus quake propagate as Rayleigh waves in the Venus surface layers and generate infrasonic waves traveling upwards through the dense atmosphere. These low frequency sound waves can be detected by a balloon (upper left) floating within the Venus clouds at an altitude of 55 km where temperatures are similar to those on the Earth's surface. As the infrasonic waves penetrate the clouds and enter the upper atmosphere they produce thermal

variations and molecular excitations. These signals can be viewed from space by infrared imaging sensors as expanding patterns of concentric circles on the orbiting spacecraft (upper right).

- Barometric pressure changes might be detected with a series of balloons in the cloud layer at 55 km (34 mi) above the surface, like those launched by the Soviet Union in Venus' atmosphere in the 1980s.
- Under discussion is another way to analyze Venus's infrasonic waves, by detecting airglow.
- In both cases, the first goal will be determine what the noise-to-signal ratio might be for these two techniques. Researchers want to know if the instruments onboard a balloon or satellite will be sensitive enough to detect and identify a seismic signal in the midst of other infrasonic waves, and how large of a seismic event might be detected by these observations.
- If these techniques can help scientists get a better sense of seismic activity on Venus, it could tell them more about **the history and current state of Venus' interior**.
- Venus' inner evolution would be especially interesting to compare with Earth's, to discover more about the diversity of planet formation **and why certain features--such as tectonic plates and a dynamo mechanism in the core--exist on Earth but not on Venus.** ##

## Venus' Volcanoes Are Likely Still Active

24 June, 2015 - [www.space.com/29742-venus-volcanoes-still-active.html](http://www.space.com/29742-venus-volcanoes-still-active.html)

The European Space Agency's **Venus Express** Spacecraft observed temperatures spiking by several hundred degrees Fahrenheit in some spots on the scorching-hot planet's surface.

- The hotspots ranged from 1–200 sq. km (0.39 to 115 sq mi.).
- A closer look at these regions showed that they were likely hot from lava running across the surface,
- Scientists found the spots in a region called Ganiki Chasma, which is already known to be quite young in geological terms. The zone was previously examined by the Soviet Union's Venera spacecraft in the 1980s, and by NASA's Magellan mission in the 1990s.
- The rifts in Ganiki Chasma are probably created when the crust is stretched by internal pressure, forcing magma to the surface, researchers said. This same process has been observed on Earth.
- There is strong evidence that Venus is volcanically, and thus internally, active today.
- This is a major finding that helps us understand the evolution of planets like our own.
- Ganiki Chasma also was discussed in a presentation at the Lunar and Planetary Science Conference last year, revealing four hotspots in the region that stood out even in Venus' 427°C (800°F) environment.
- Venus Express spent eight years orbiting Earth's "sister planet" before running out of fuel and falling into the atmosphere this past December.
- In 2014, the spacecraft performed risky dives into the Venus' atmosphere to gather more information about the planet's composition, and to gather data that could aid the design of possible future landers.

## VEXAG – the Venus EXploration Analysis Group

[www.lpi.usra.edu/vexag/](http://www.lpi.usra.edu/vexag/)

[This is not news, but a look at what may be in the work for further/future exploration of Venus.]

The Venus Exploration Analysis Group (VEXAG) was established by NASA in July 2005 to identify scientific priorities and strategy for exploration of Venus. VEXAG is currently composed of a chair and five focus groups. The focus groups will actively solicit input from the scientific community. VEXAG will report its findings and provides input to NASA, but will not make recommendations.

### VEXAG Venus Exploration Documents

#### Goals, Objectives, and Investigations for Venus Exploration

[www.lpi.usra.edu/vexag/reports/GOI-140625.pdf](http://www.lpi.usra.edu/vexag/reports/GOI-140625.pdf)

#### Roadmap for Venus Exploration

[www.lpi.usra.edu/vexag/reports/Roadmap-140617.pdf](http://www.lpi.usra.edu/vexag/reports/Roadmap-140617.pdf)

#### Venus Technology Plan: 2014

[www.lpi.usra.edu/vexag/reports/Venus-Technology-Plan-140617.pdf](http://www.lpi.usra.edu/vexag/reports/Venus-Technology-Plan-140617.pdf)

#### Venus Exploration Themes: 2014

[www.lpi.usra.edu/vexag/reports/VEXAG%20 Themes\\_140825.pdf](http://www.lpi.usra.edu/vexag/reports/VEXAG%20Themes_140825.pdf)

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## JUPITER

## JUPITER'S MOONS

## Europa's Elusive Water Plume Paints Grim Picture For Life

[www.spacedaily.com/reports/Europas\\_Elusive\\_Water\\_Plume\\_Paints\\_Grim\\_Picture\\_For\\_Life\\_999.html](http://www.spacedaily.com/reports/Europas_Elusive_Water_Plume_Paints_Grim_Picture_For_Life_999.html)

7 April, 2015 – A meteorite may have been responsible for a water plume briefly spotted above Europa two years ago, implying it takes a very rare event to breach the ice on the Jovian moon.

- Astrobiologists worldwide received news in December 2013 that water vapor was detected in Hubble Space Telescope observations of Jupiter's moon Europa, considered one of the top potential locations in our solar system for life.
- Follow-up observations of Europa have revealed no plume emanating from the Moon. A new paper reveals that Europa's atmosphere is 100 times less abundant than claims in previous publications, and composed mainly of atomic (O) rather than molecular oxygen (O<sub>2</sub>).
- More, the magnetosphere plasma, or superheated gas, at Europa's orbit is very hot, with properties indicating that the plasma is mainly composed of ions, or charged particles, from a nearby moon, Io.
- Based on the plasma properties, the rate of injection of neutral gas from Europa's surface is very low, meaning that Europa's atmospheric plasma has a low escape rate into its magnetosphere.
- No one knew what the plasma was made of before Cassini's measurements, which led some researchers previously to believe that the plasma came from Europa.
- Plasma, superheated gas, can be comprised of different molecules, including hydrogen and oxygen, but Cassini's spectroscope was not designed to measure which.
- Because molecular hydrogen and atomic hydrogen were not found in Cassini's measurement of the plasma, this means that the plasma did not come from Europa as was previously suspected.
- The plasma that was detected was made of sulfur dioxide – a product of volcanoes on Io.
- However, a meteorite that briefly threw water aloft from Europa's surface cannot be ruled out.

### Volcanic plasma

- This would mean that any output that scientists see in the area is from Io, not Europa, which has grim implications for life.
- Europa would need to have fissures in its surface to allow for contact between its hypothetical underground ocean and the combined effects of the magnetosphere and solar input on its surface. The energy input would include gravitational flexure by Jupiter in addition to the sun and magnetosphere. If the plume is a rare event, this means there are likely few or no cracks in the surface. Europa might be a socked-in icy ball with a barren ocean below.

**Editor: Okay, away with this nonsense!** Europa's ice crust is very highly fractured, indicating that blocks of ice have separated for long enough for water from the ocean below to freeze in those fractures. Plumes or no plumes, these events could be very rare by our humanly impatient reckoning, yet on a billions of years schedule, have released water from below countless times.

How can anyone say that this infrequency means Europa's ocean must be sterile? That is one of the most extreme non-sequiturs I have ever heard!

For shame on those who came to this absurd conclusion. And for shame too on the publications that have printed this nonsense. - Peter Kokh

## Jupiter Moon Europa's Dark Lines May Be Salt from Underground Sea

11 MAY – [www.space.com/29392-jupiter-moon-europa-salty-dark-streaks.html](http://www.space.com/29392-jupiter-moon-europa-salty-dark-streaks.html)

The reddish-brown lines that crisscross the icy surface of Jupiter's moon Europa may be radiation-bombarded sea salt from an underground ocean.

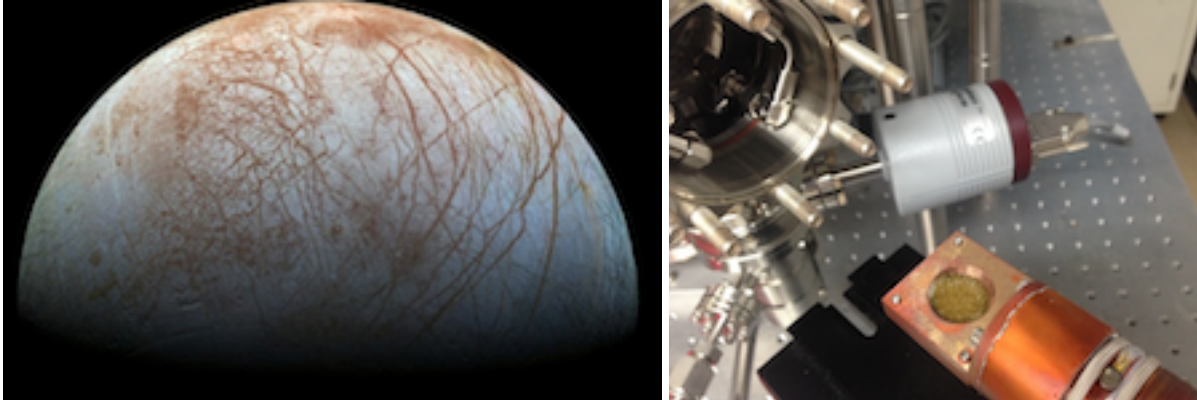
- Researchers probing the nature of the mysterious Europa features put run-of-the-mill salt (sodium chloride) and salt-water mixtures in a vacuum chamber chilled to minus 270 degrees Fahrenheit (minus 173 degrees Celsius), then blasted the samples with electrons.

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### “Europa in a can”

- NASA's Jet Propulsion Laboratory (JPL) (Pasadena, CA) created a lab setup that mimics conditions on Europa's surface in terms of temperature, pressure and radiation exposure.
- Researchers probing the nature of the mysterious Europa features put salt (sodium chloride) and salt-water mixtures in a vacuum chamber chilled to  $-73\text{ }^{\circ}\text{C}$  ( $-270^{\circ}\text{F}$ ), blasting the samples with electrons.
- A few dozen hours of radiation treatment — the equivalent of perhaps 100 years of Europa-level exposure — turned the salt from white to a yellow-brown color similar to that of the Europa lines, which trace geologically young fractures on the moon's surface.
- The chemical signature of radiation-baked sodium chloride seems to be a compelling match to spacecraft data for Europa's mystery material.
- Further, the salt samples turned darker the longer they were exposed to the electron beam
- Researchers might be able to estimate the ages of some Europa features based on their color



The surface of Jupiter's icy moon Europa is crisscrossed by mysterious reddish-brown streaks.

A sample of salt turned brownish after exposure to Europa-like radiation,

Suggesting the dark streaks on the Jupiter moon's surface may be deposits of sea salt.

### Is there Life on Europa?

- The new study, accepted for publication in the journal **Geophysical Research Letters**, could help researchers better understand processes occurring on Europa, one of the best bets to host alien life.
- This research focuses on questions we can answer, like whether or not Europa is inhabitable
- Once we have those answers, we can tackle **the bigger question** – “**is there life in the ocean beneath Europa's ice shell.**”

### “The” Mission

- NASA is developing a mission to Europa, to launch in the early to mid-2020s. Details not set. The mission will send a spacecraft to Jupiter orbit, then make many flybys of Europa over the course of 3-4 years, assessing the moon's habitability and perhaps also searching for signs of life. ##

## Europa Mission Begins with Selection of Science Instruments

[www.spacedaily.com/reports/Europa\\_Mission\\_Begins\\_with\\_Selection\\_of\\_Science\\_Instruments\\_999.html](http://www.spacedaily.com/reports/Europa_Mission_Begins_with_Selection_of_Science_Instruments_999.html)

27 May, 2015 – NASA has selected **nine science instruments for a mission to Jupiter's moon Europa, to investigate whether the mysterious icy moon could harbor conditions suitable for life.**

- NASA's Galileo mission's 11 flybys yielded strong evidence that Europa, about the size of Earth's moon, has an ocean beneath a frozen crust of unknown thickness. If proven to exist, this **global ocean could have more than twice as much water as Earth.**
- With abundant **salt water, a rocky sea floor**, and the **energy and chemistry provided by tidal heating**, Europa could be the best place in the solar system to look for present day life beyond Earth.
- NASA's fiscal year 2016 budget request includes **\$30 million to formulate a mission to Europa.**
- The mission would send a spacecraft into a long, looping orbit around Jupiter in 45 repeated close flybys of Europa over a 3-year period. at altitudes ranging from 25-2,700 km (16 -1,700 mi).
- The payload of selected science instruments includes cameras and spectrometers to produce high-resolution images of Europa's surface and determine its composition.

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and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- An ice penetrating radar will determine the thickness of the moon's icy shell and search for subsurface lakes similar to those beneath Antarctica. T
- The mission also will carry a magnetometer to measure strength and direction of the moon's magnetic field, which will allow scientists to determine the depth and salinity of its ocean.
- A thermal instrument will scour Europa's frozen surface for recent eruptions of warmer water
- Other instruments will search for evidence of water and tiny particles in the moon's thin atmosphere.
- NASA's Hubble Space Telescope observed water vapor above the south polar region of Europa in 2012, providing the first strong evidence of water plumes. If the plumes' existence is confirmed – and they're linked to a subsurface ocean – it will help scientists investigate the chemical makeup of Europa's potentially habitable environment while minimizing the need to drill through layers of ice.
- Last year, NASA invited researchers to submit proposals for instruments to study Europa. Thirty-three were reviewed and, of those, nine were selected for a mission that will launch in the 2020s.

### The NASA selectees are:

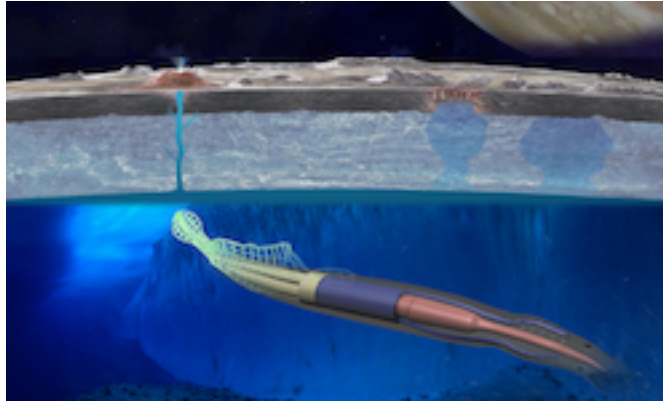
1. **Plasma Instrument for Magnetic Sounding (PIMS)** – Dr. Joseph Westlake of Johns Hopkins Applied Physics Laboratory (APL), Laurel, Maryland. This instrument works in conjunction with a magnetometer to **determine Europa's ice shell thickness, ocean depth, and salinity by correcting the magnetic induction signal for plasma currents around Europa.**
  2. **Interior Characterization of Europa using Magnetometry (ICEMAG)** – Dr. Carol Raymond of NASA's Jet Propulsion Laboratory (JPL), Pasadena, California. This magnetometer will **measure the magnetic field near Europa and – in conjunction with the PIMS instrument – infer the location, thickness and salinity of Europa's subsurface ocean using multi-frequency electromagnetic sounding.**
  3. **Mapping Imaging Spectrometer for Europa (MISE)** – Dr. Diana Blaney of JPL. This instrument will probe the **composition of Europa, identifying and mapping the distributions of organics, salts, acid hydrates, water ice phases, other materials to determine the habitability of Europa's ocean.**
  4. **Europa Imaging System (EIS)** – Dr. Elizabeth Turtle of APL. The wide and narrow angle cameras on this instrument will **map most of Europa at 50 meter (164 foot) resolution, and will provide images of areas of Europa's surface at up to 100 times higher resolution.**
  5. **Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON)** – iDr. Donald Blankenship of the University of Texas, Austin. This dual-frequency ice penetrating radar instrument is designed to **characterize and sound Europa's icy crust from the near-surface to the ocean, revealing the hidden structure of Europa's ice shell and potential water within.**
  6. **Europa Thermal Emission Imaging System (E-THEMIS)** – Dr. Philip Christensen of Arizona State University, Tempe. This "heat detector" will **provide high spatial resolution, multi-spectral thermal imaging of Europa to help detect active sites, such as potential vents erupting plumes of water into space.**
  7. **MASPEX (Mass Spectrometer for Planetary Exploration/Europa)** – Dr. Jack (Hunter) Waite of the Southwest Research Institute (SwRI), San Antonio. This instrument will **determine the composition of the surface and subsurface ocean by measuring Europa's extremely tenuous atmosphere and any surface material ejected into space.**
  8. **Ultraviolet Spectrograph/Europa (UVS)** – Dr. Kurt Retherford of SwRI. This instrument will adopt the same technique used by the Hubble Space Telescope to detect the likely presence of water plumes erupting from Europa's surface. UVS will be able to **detect small plumes and will provide valuable data about the composition and dynamics of the moon's rarefied atmosphere.**
  9. **SURFACE DUST MASS ANALYZER (SUDA)** – Dr. Sascha Kempf of the University of Colorado, Boulder. This instrument will measure the **composition of small, solid particles ejected from Europa, providing the opportunity to directly sample the surface and potential plumes on low-altitude flybys.**
- Separate from the selectees listed above, the **SPACE ENVIRONMENTAL AND COMPOSITION INVESTIGATION NEAR THE EUROPEAN SURFACE (SPECIES)** instrument has been chosen for further technology development. Led by principal investigator Dr. Mehdi Benna at NASA's Goddard Space Flight Center in Greenbelt, Maryland, this combined neutral mass spectrometer and gas chromatograph will be developed for other mission opportunities.

**Editor:** I hope to live to see the results! Europa is one of my primary interests for decades now!

## A Robotic Explorer under the crust of Europa or Enceladus or other outer system moons with an ice crust hiding a global ocean

One of the technologies NASA is exploring

[www.nasa.gov/press-release/nasa-selects-advanced-space-technology-concepts-for-further-study](http://www.nasa.gov/press-release/nasa-selects-advanced-space-technology-concepts-for-further-study)



8 May, 2015 – This artist rendering depicts 2015 NIAC Phase I Fellow Mason Peck's **soft-robotic rover** for planetary environments for missions that cannot be accomplished with conventional power systems. It resembles a squid, with tentacle-like structures that serve as electrodynamic 'power scavengers' to harvest power from locally changing magnetic fields. The goal is to enable amphibious exploration of gas-giant moons like Europa.

## NASA Aiming for Multiple Missions to Jupiter Moon Europa

9 June, 2015 - [www.space.com/29604-nasa-jupiter-moon-europa-surface-mission.html](http://www.space.com/29604-nasa-jupiter-moon-europa-surface-mission.html)

NASA's highly anticipated mission to Europa in the next decade may be just the beginning of an ambitious campaign to study the ocean-harboring Jupiter moon.

- In 2020–25 NASA plans to launch a mission to conduct dozens of flybys of Europa, which many astrobiologists regard as the solar system's best bet to host life beyond Earth.
- NASA officials hope this effort paves the way for future missions to Europa — including one that lands on the icy moon to search for signs of life.

### Studying Europa from afar

- At 3,100 km (1,900 mi) wide, Europa is only slightly smaller than the Moon. But unlike the Moon, Europa is covered by a shell of ice, beneath which sloshes an ocean of liquid water.
- Scientists think this ocean is in contact with Europa's rocky mantle, making possible a variety of complex chemical reactions. Indeed, the European sea may be capable of supporting life as we know it, which explains why astrobiologists have long dreamed of launching a probe to the icy world.
- The gear includes high-resolution cameras, ice-penetrating radar, a heat detector, other equipment.
- The probe will reach Jupiter orbit and then use these instruments to study Europa's frigid surface and underground ocean during 45 flybys over the course of about two and a half years.
- The goal of the Europa flyby mission to better understand this **moon's ability to support life**, not search for signs of alien organisms.
- As exciting as a Europa life hunt would be, NASA is just not ready to take that step yet.

### Going back to Europa?

- NASA does not envision a one-and-done effort at Europa.
- The science community don't have a lot of faith, either in NASA or in Congress, to fund another Europa mission, so they'd like to get everything on this first mission.
- We need to do incremental approaches to studying Europa," NASA Administrator Bolden says.
- NASA is already thinking, in a preliminary sense, about possible next steps at Europa,.
- But the initial Europa effort, with its 45 flybys, will basically serve as an orbital mission in terms of science return, Green said, so putting a probe down on the moon's surface is the logical next step.

- The flyby probe will, in some ways, serve as a scout, returning supersharp images and other data — such as information about the thickness of Europa's ice shell — that will help researchers plan out a potential surface mission in the future (as well as pick a site to probe deeper.)
- We don't know what the surface of Europa looks like — if it's smooth, if it's very rough, if it's full of spikes, Without knowing what the surface even looks like, it's difficult to design a capable lander/
- Ideally, a landed mission to Europa would not be restricted to its surface, but make contact with the ocean, or at least with smaller pockets of liquid water trapped under the ice.
- The results from this particular mission could lead, in the next decade, to some new and exciting concepts about potentially getting underneath the ice shell. ##

#### Europa Infographic:

<http://i.space.com/images/i/000/031/364/i300/europa-moon-of-jupiter-141124a-02.jpg?1416867685>

#### Similar story:

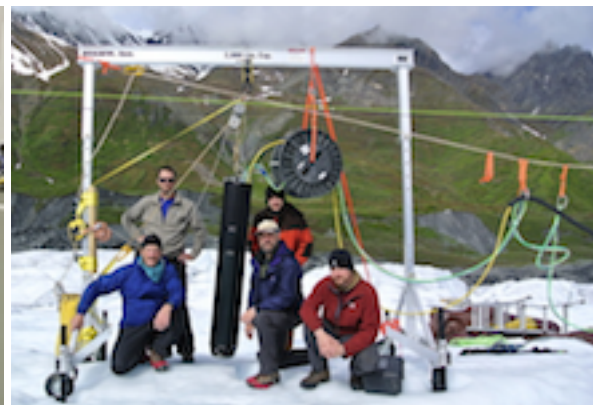
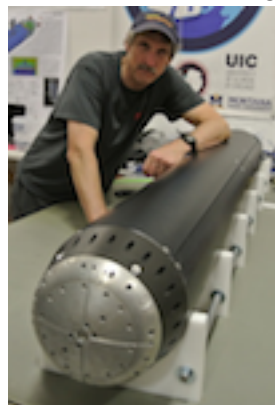
[www.spacedaily.com/reports/NASA\\_Scientists\\_Seek\\_to\\_Unveil\\_Mysteries\\_of\\_Europas\\_Ocean\\_999.html](http://www.spacedaily.com/reports/NASA_Scientists_Seek_to_Unveil_Mysteries_of_Europas_Ocean_999.html)

## Tunneling Cryobot Robot May Explore Icy Moons

13 June, 2015 - [www.space.com/29644-cryobot-tunneling-robot-explore-icy-moons.html](http://www.space.com/29644-cryobot-tunneling-robot-explore-icy-moons.html)

A robotic "cryobot," designed to tunnel down through thick ice caps is undergoing tests on the Matanuska glacier in Alaska. It paves the way towards one day exploring the underground oceans of Jupiter's moon, Europa, or other icy moons of the Outer Solar System, such as Saturn's Enceladus.

- Europa is back on the menu for exploration. NASA's budget for the 2016 fiscal year includes about \$30 million for further development of the Europa Clipper concept, a mission to Europa that will seek possible signs of the icy moon's habitability.
- However, being potentially habitable is not the same as being inhabited. To find life, a mission will ultimately have to land on the surface and go under the ice to the ocean below.  
*Editor: No, we could sample the dark cracks in the ice which are filled with water gushing up from below to see if they contained frozen organisms.*
- **Europa Clipper**, if and when it launches sometime around 2025, will carry out reconnaissance of the surface for safe and scientifically interesting places to land. But Clipper will not be carrying a lander.
- "Assuming Europa is found to be potentially habitable, the next mission that follows may be able to land and perhaps try to get beneath the ice," says Louise Prockter, a planetary scientist at Johns Hopkins University Applied Physics Laboratory and Pre-Project Deputy Scientist for the Clipper mission.
- The challenge of getting underneath the ice on Europa is a daunting one. First, any cryobot would have to tunnel through 20–30 km (12.4–18.6 mi) of ice. Even the thinner areas may be some km thick.
- A major challenge is **how such a probe would be able to communicate to the surface** as it descends
- "The cryobot would also need to be able to withstand significant pressures underneath the ice.



**Left:** An earlier Europa Explorer concept

**Center and Right:** Dr Bill Stone and crew with VALKYRIE.

- Bill Stone reckons otherwise. An experienced explorer, caver and engineer, as well as the founder of Stone Aerospace — a company that designs robots and vehicles to explore frontiers here on Earth.



- Stone heads back out to the Matanuska glacier this summer with his team of explorers and scientists to continue testing the most advanced cryobot in the world. Named **VALKYRIE** (Very deep Autonomous Laser-powered Kilowatt-class Yo-yoing Robotic Ice Explorer) and funded by NASA's Astrobiology Science and Technology for Exploring Planets (ASTEP) program, this cryobot uses **lasers** and **fiber optics to cleanly melt its way through the ice**.
- In 2003, Stone Aerospace received NASA funding for DEPTHX, DEep Phreatic THERmal eXplorer, an autonomous robot designed to explore underwater sinkholes but with the potential to one day explore Europa's ocean. DEPTHX used glass fiber optics to transmit data using five watt laser diodes.
- Far more laser power could be transmitted through the fibers, to a theoretical limit of 4.6 megawatts.
- Previous cryobot designs carried their power source inside them, so the amount of energy they could generate was severely limited by their size and mass.
- However, VALKYRIE has the advantage of being able to leave its power source on the surface and transmit the energy via a laser down an optical fiber just microns wide.
- Currently, VALKYRIE works with a 5 kw laser, but the power needed on Europa would be between 250 kw and a megawatt.
- The cryobot uses the laser energy to **heat water with which to melt the ice in front of it**.
- The water re-freezes behind it around the fiber, maintaining communications and power flow.
- In 2014 VALKYRIE descended to a depth of 31 m into the Matanuska glacier.
- They've been doing a 5 kilowatt test only because of budget limitations.
- With more money they could build a 250 kw laser-powered cryobot to go through kilometers of ice in Antarctica.
- Once it breaks through the bottom of the ice crust, there is the task of exploring the ocean. Stone Aerospace also has this covered with **DepthX** and their latest autonomous underwater vehicle, **ARTEMIS** (Autonomous Rover/airborne-radar Transects of the Environment Beneath the McMurdo Ice Shelf), which is a prototype for an underwater mothership that could deploy smaller 'marsupial' probes to explore such areas of interest as hydrothermal vents.
- ARTEMIS is the primary vehicle in a NASA/ASTEP project named SIMPLE: Sub-ice Investigation of Marine and Planetary-analog Ecosystems.
- The underground ocean is not the only region of interest on Europa. In 2013 the Hubble Space Telescope found evidence (not yet confirmed) that geysers of water vapor are erupting from Europa's south pole, similar to the water vapor eruptions emanating from Saturn's moon Enceladus.
- In the meantime, Stone and his team continue to fine-tune their prototypes. The goal this year for VALKYRIE is to incorporate a **protein fluorescent cytometer**, a life-detecting instrument that looks for ultraviolet backscatter to detect the presence of microbes deposited in the ice of Matanuska glacier.
- Meanwhile, ARTEMIS heads to Antarctica's Ross Ice Shelf in October 2015 to map the underside of the ice shelf to provide data for calibrating Europa Clipper's ice-penetrating radar. ##.

## NASA's Europa Mission Approved for Next Development Stage

20 June, 2015 - [www.space.com/29713-europa-mission-approved-for-development.html](http://www.space.com/29713-europa-mission-approved-for-development.html)

A plan to launch a spacecraft to Europa in the 2020s passed a major hurdle, as NASA approved the mission concept and gave the go ahead to move forward into the formulation stage of development.

- Sending a flyby mission to this icy moon is considered key in helping scientists determine how likely life is to exist there. If the probe shows that conditions on Europa would permit microbial life, other moons, such as Saturn's Enceladus, might also host - an exciting step from concept to mission in our quest to find signs of life beyond Earth.
- Observations of Europa have provided us with tantalizing clues over the last two decades, and the time has come to seek answers to one of humanity's most profound questions.
- NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California will manage the Europa project.
- A suite of instruments chosen to fly aboard the proposed spacecraft was announced in May.
- While the Voyager spacecraft did a quick flyby of Europa in the 1980s, it was NASA's Galileo probe in the 1990s that provided more evidence for a global ocean underneath this moon's thick icy surface.

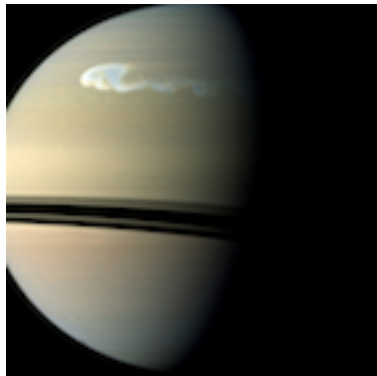
- Two years ago, researchers using the Hubble Space Telescope released images of a water plume at Europa, a find that has not been repeated.
- The White House's 2016 federal budget request includes \$18.5 million for the mission's development. The previous year, Congress provided \$100 million after a request was made for just \$15 million.
- The plan would see the spacecraft do 45 flybys of Europa while orbiting Jupiter every two weeks.
- Science goals include taking images of the icy surface, and remotely probing the moon's interior.

## SATURN & ITS MOONS

### Mystery of Saturn's Epic Planet-Encircling Storms Explained

13 April, 2015 - [www.space.com/29088-saturn-giant-storms-mystery-solved.html](http://www.space.com/29088-saturn-giant-storms-mystery-solved.html)

- Giant storms on Saturn - "Great White Spots" - may be caused by moisture in the atmosphere.
- Stretching across the planet, these storms have erupted six times since first discovered in 1876.
- They resemble thunderstorms on Earth, except that each of these storms is about the size of Earth.
- The most recent storm began in 2010, with Cassini in orbit in time to watch
- The storms grew long enough in six months to encircle the planet.
- The Great White Spots that astronomers have seen on Saturn in the past 140 years alternate between Saturn's equator and its mid-latitudes.
- They recur every 20 to 30 years, and it was a mystery why it took so long for these storms to ensue.
- New research suggests that water vapor in Saturn's atmosphere might be what suppresses these giant storms from developing for decades.



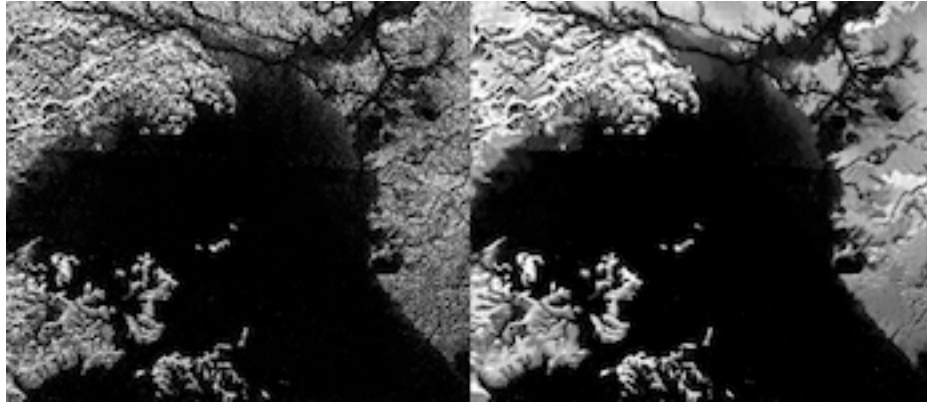
The Great White Spot was the size of Earth

- Storms are caused by the way hot and cold gases churn around in atmospheres - convection.
- On Saturn, water molecules are relatively heavy compared with the hydrogen and helium molecules that dominate the planet's atmosphere, so the water sinks down to form a separate layer.
- The wet layer does not mix with dry areas. Lack of convection suppresses giant storms for decades.
- When moisture stifles convection in the atmosphere, warm air does not rise as it otherwise would. Eventually Saturn's upper atmosphere cools and gets more dense, eventually heavy enough to sink.
- That circulation causes warm, moist air to rise rapidly, eventually triggering a giant thunderstorm.
- The research team found its model matches Cassini observations of the 2010 Great White Spot!
- The team's findings also explain another mystery: why so little ammonia vapor has been seen in the wake of these storms. The rising warm, moist air brings ammonia vapor along with it to the cold upper atmosphere, where it rains out, the researchers say.
- This work could help scientists estimate how much water Saturn has.
- As water on Saturn is an imprint from the early solar system, its abundance will tell us about Saturn's formation history.
- The scientists also noted that the absence of planet-encircling storms on Jupiter might be due to the lower levels of water vapor in the larger planet's atmosphere compared to Saturn.
- NASA's Juno probe, to arrive at Jupiter in 2016, will measure Jupiter's water levels, to test this idea. ##

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

## New Technique Shines Light on Titan, Largest Moon of Saturn (Photo)

4 April, 2015 – [www.space.com/29019-saturn-moon-despeckling-photo-technique.html](http://www.space.com/29019-saturn-moon-despeckling-photo-technique.html)



Old and new view of Ligeia Mare, one of the large hydrocarbon seas on Titan

**A new image-processing technique is bringing Titan, into clearer view than ever before.**

- More than 10 years of observations by the Cassini probe have mapped almost half of Titan's surface.
- The Cassini probe, which is exploring the Saturn system, has uncovered the largest dune fields in the solar system and hydrocarbon lakes that grow and shrink with the seasons on Titan.
- But now, recent improvements in image processing have made the radar images look better than ever.
- Any picture will contain some amount of noise, typically manifesting itself as a grainy, specklelike appearance, making it hard for scientists to spot small features or identify changes across the images.
- The grainy appearance of the images particularly bothered Antoine Lucas, at the astrophysics division of France's nuclear center. "Noise in the images gave me a headache,"
- Lucas dug through literature published in the mathematics community and discovered that a team near Paris was working on just what he needed: **a de-noising algorithm**.
- Lucas worked closely with that team to apply their algorithm to the Cassini radar data, making all the difference, going further in our understanding of Titan's surface using the new technique.
- The technique, called "despeckling," takes a lot of computation. So the radar team will have to prioritize which images deserve preferential treatment in receiving the additional algorithm.
- Nonetheless, it "provides a fresh look at the data, helpign us better understand the original images.
- "With this innovative new tool, we will look for details that help us to distinguish among the different processes that shape Titan's surface." ##

## Violent Methane Storms on Titan May Explain Strange Dunes

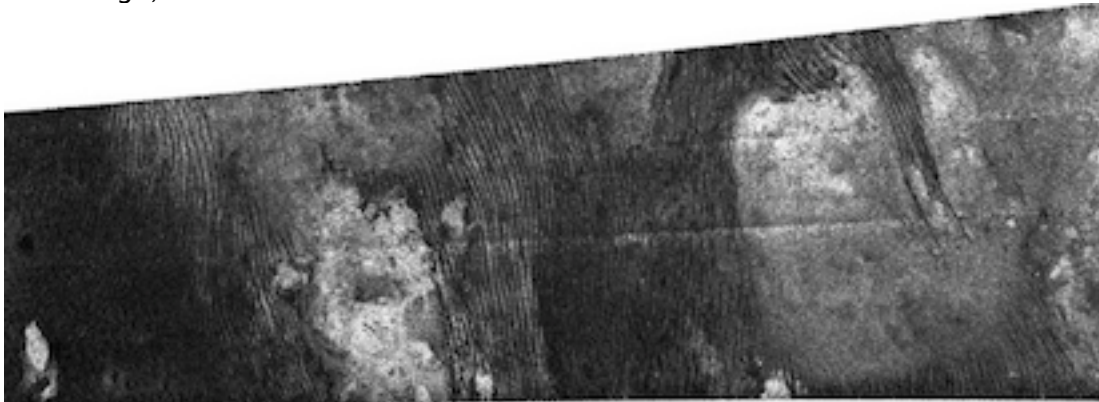
13 April, 2015 – [www.space.com/29090-titan-methane-storms-sculpt-sand-dunes.html](http://www.space.com/29090-titan-methane-storms-sculpt-sand-dunes.html)

[www.spacedaily.com/reports/Violent\\_methane\\_storms\\_on\\_Titan\\_may\\_solve\\_dune\\_direction\\_mystery\\_999.html](http://www.spacedaily.com/reports/Violent_methane_storms_on_Titan_may_solve_dune_direction_mystery_999.html)



A methane ice cloud is seen over the north pole of Titan in this view captured by the Cassini spacecraft in December 2006. Scientists suspect that intense methane storms on Titan may also sculpt towering dunes at the moon's equator.

- Rare tropical methane storms could help solve the mystery of how strange, giant dunes form on Titan.
- When NASA's Cassini began exploring Titan in 2004, its most dramatic discovery was the field of dunes that covers nearly 15% of Titan's surface along its equator.
- These dark massive dunes — the largest of their kind in the solar system — are made of exotic sand composed of hydrogen and carbon. They can be more than **100 m** (330 ft) high and are typically 30–50 km (18–31 mi) long.
- They pose one of Titan's greatest mysteries, as they seem to grow eastward, whereas models of Titan's atmosphere predict that surface winds at its equatorial latitudes would blow westward.
- However, prior research found that Titan's winds blow eastward at altitudes above about 5 km (3 mi).
- This finding has led scientists to wonder if these high winds might somehow help solve this puzzle, even though they blow far above these dunes.
- Now, researchers have found that rare methane storms could help sculpt the moon's surface.
- Clouds and storms are rare on Titan, and they were not expected to have an impact on dunes.
- Titan is the only moon in the solar system with a thick atmosphere. It is composed mostly of nitrogen, with a trace of methane that can form into clouds.
- During the equinox, when days and nights are about the same length, Titan experiences huge, violent methane storms in the tropical regions around its equator.
- Computer models of weather on Titan revealed that methane clouds can reach altitudes of 25 km (15.5 mi), where the high, fast eastward winds blow.



Sand dunes on Titan dominate this Cassini image in 2009. This image is centered on a region just north of the equator. The giant dunes at the equator may be sculpted by these intense methane storms.

- Researchers found that, as a result, methane storms can produce downdrafts that flow eastward on strong gusts after they reach Titan's surface.
- They estimated that these eastward gusts can reach up to 36 km/h (22 mph) — 10 times faster than the more common winds close to Titan's surface.
- The intensity of the storm gusts were surprising — for Titan, it is like a hurricane.
- These storm gusts may explain the shape, size, spacing and eastward growth of Titan's dunes.
- If scientists can get a better understanding of how these dunes form on Titan, it could provide more insight into the moon's present and past atmosphere.
- There are long dunes on Titan which formed over a very long period of time, likely more than 1 million years. Others are shorter and formed during the last 100,000 years."
- In this new study, the researchers developed a new growth mechanism for dunes that may answer questions about how dunes form on Earth. ##

## Could Alien Life on Oily Exoplanets Have Ether-based 'DNA'

13 May, 2015 - [www.space.com/29389-alien-life-hydrocarbon-exoplanets-ether-dna.html](http://www.space.com/29389-alien-life-hydrocarbon-exoplanets-ether-dna.html)

Check this Titan-relevant report in the STARBOUND Exo-planet section below



## Dissolving Titan

[www.esa.int/Our\\_Activities/Space\\_Science/Dissolving\\_Titan](http://www.esa.int/Our_Activities/Space_Science/Dissolving_Titan)

17 June, 2015 – Saturn’s moon Titan is home to seas and lakes filled with liquid hydrocarbons, **but what makes the depressions they lie in?**

- A new study suggests Titan’s surface dissolves in a similar process that creates sinkholes on Earth.
- **Apart from Earth, Titan is the only Solar System body known to possess surface lakes and seas,**
- At roughly  $-180^{\circ}\text{C}$ , the surface of Titan is very cold and **liquid methane and ethane**, rather than water, dominate the ‘hydrological’ cycle.
- Methane and ethane-filled topographic depressions are distinctive features near the moon’s poles.
- Two forms have been identified by Cassini. **Vast seas several hundred kilometres across and up to several hundred metres deep, fed by river-like dendritic channels.**
- There are numerous smaller, shallower lakes, with rounded edges and steep walls, in flat areas.
- Many empty depressions are also observed.
- The lakes are generally not associated with rivers, and are thought fill up by **rainfall and liquids flooding up from underneath.**
- Some of the lakes fill and dry out again during the 30-year seasonal cycle on Saturn and Titan.
- How the depressions hosting the lakes came about in the first place is poorly understood.
- A team of scientists found that Titan’s lakes are reminiscent of ‘karstic’ landforms seen on Earth.
- These are terrestrial landscapes that result from erosion of soluble rocks such as limestone and gypsum in groundwater and rainfall percolating through rocks.
- Over time, this leads to features including sinkholes and caves under humid climates, and salt-pans under more arid climates.
- The rate of erosion depends on factors such as the chemistry of the rocks, the rainfall rate, and the surface temperature. While all of these aspects clearly differ between Titan and Earth, the underlying process may be surprisingly similar.
- A ESA-led team calculated how long it would take for patches of Titan’s surface to dissolve to create these features, assuming that the surface is covered in solid organic material, and that the main dissolving agent is liquid hydrocarbons, and took into account present-day models of Titan’s climate.
- It would take around 50 million years to create a 100 m-deep depression at Titan’s relatively rainy high polar latitudes, consistent with the youthful age of Titan’s surface.
- They found that the dissolution process occurs on Titan **some 30 times slower than on Earth** due to the longer length of Titan’s year and the fact it only rains during Titan summer.
- “Nevertheless, we believe that dissolution is a major cause of landscape evolution on Titan, and could be the origin of its lakes.” ##

## Cassini Prepares for Last Up-close Look at Hyperion

[www.spacedaily.com/reports/Cassini\\_Prepares\\_for\\_Last\\_Up\\_close\\_Look\\_at\\_Hyperion\\_999.html](http://www.spacedaily.com/reports/Cassini_Prepares_for_Last_Up_close_Look_at_Hyperion_999.html)

29 May, 2015 – NASA’s Cassini spacecraft made its final close approach to Saturn’s large, irregularly shaped moon Hyperion on May 31.

- Cassini will pass Hyperion at a distance of about 34,000 km (21,000 mi) Images from the encounter should arrive on Earth within 24 to 48 hours.
- Mission scientists hope to see different terrain on Hyperion than previously explored in detail.
- Hyperion (270 km ~168 mi across) rotates chaotically, essentially tumbling unpredictably through space as it orbits Saturn.
- Thus it’s challenging to target a specific region of the moon’s surface, and most of Cassini’s previous close approaches have encountered more or less the same familiar side of the craggy moon.

- Cassini scientists attribute Hyperion's unusual, sponge-like appearance to the fact that it has **an unusually low density for such a large object – about half that of water.**
- Its low density makes Hyperion quite porous, with weak surface gravity. These characteristics mean impactors tend to compress the surface, rather than excavating it, and most material that is blown off the surface never returns.
- The closest-ever Hyperion flyby took place on September 26, 2005, at a distance of 505 km (314 mi).
- Cassini's next notable flyby after May 31 is slated for June 16, when the spacecraft will pass 321 miles (516 kilometers) above icy Dione. That flyby will represent the mission's penultimate close approach to that moon.
- In October, Cassini will make two close flybys of the active moon Enceladus, with its jets of icy spray, coming as close as 48 km (30 mi) in the final pass.
- In late 2015, the spacecraft will again depart Saturn's equatorial plane – where moon flybys occur most frequently – to begin a year-long setup of the mission's daring final year. For its grand finale, Cassini will repeatedly dive through the space between Saturn and its rings. ##

## Saturn's "sponge like" moon Hyperion

28 Apr, 2015 – [www.esa.int/spaceinimages/Images/2015/04/Saturn\\_s\\_sponge-like\\_moon\\_Hyperion](http://www.esa.int/spaceinimages/Images/2015/04/Saturn_s_sponge-like_moon_Hyperion)



Saturn's moon Hyperion may be a potato-shaped lump of porous rock but, as discovered by Cassini, it is more intriguing than it seems

[http://en.wikipedia.org/wiki/Hyperion\\_\(moon\)](http://en.wikipedia.org/wiki/Hyperion_(moon))

Dimensions 360.2 × 266 × 205.4 km (223x165x127 mi)

<http://solarsystem.nasa.gov/planets/profile.cfm?Object=Hyperion>

## Ocean on Enceladus May Have Potential Energy Source to Support Life

7 May, 2015 – [www.space.com/29334-enceladus-ocean-energy-source-life.html](http://www.space.com/29334-enceladus-ocean-energy-source-life.html)

Saturn's icy moon Enceladus is looking better and better as a potential abode for alien life.

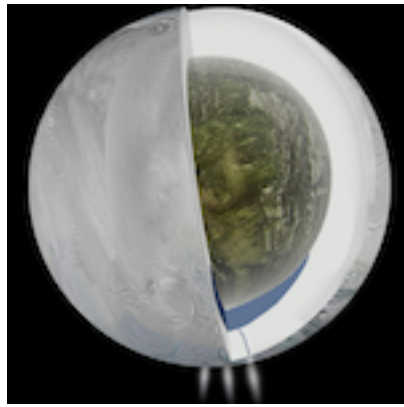
- Chemical reactions that free up energy that could potentially support a biosphere have occurred — and perhaps still are occurring — deep within the moon's salty subsurface ocean.
- This determination comes less than two months after a different research team announced that active hydrothermal vents likely exist on Enceladus' seafloor, suggesting that conditions there could be similar to those that gave rise to some of the first lifeforms on Earth.

### A Salty Ocean

- Astrobiologists regard the 314-mile-wide (505 kilometers) Enceladus as one of the solar system's best bets to host life beyond Earth.
- Enceladus is covered by an icy shell, but it's geologically quite active, as evidenced by the powerful geysers that blast continuously from its south polar region.
- These plumes contain significant amounts of water, which may originate from a subsurface ocean.
- Previous studies suggested that this ocean is in contact with Enceladus' rocky mantle, making possible all sorts of interesting chemical reactions.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



This illustration shows the possible interior of the Saturn moon Enceladus. Data gathered by NASA's Cassini probe suggests Enceladus has an ice outer shell and a rocky core with a regional water ocean sandwiched in between at high southern latitudes.

- The new paper, published in the journal *Geochimica et Cosmochimica Acta*, supports that notion.
- The researchers studied mass-spectrometry measurements made by the Cassini orbiter of the gases and ice grains in Enceladus' plumes.
- The team used this information to develop a model that estimates the saltiness and pH of Enceladus' plumes, and, by extension, the moon's underground ocean.
- The ocean is likely salty and quite basic, with a pH of 11 or 12 — roughly equivalent to that of ammonia-based glass-cleaning solutions, still within the tolerance range of some organisms on Earth.
- Enceladus' subsurface sea contains dissolved sodium chloride (NaCl) — (table salt) — just as Earth's oceans do. But it's full of sodium carbonate (Na<sub>2</sub>CO<sub>3</sub>), also known as washing soda or soda ash.
- So this alien water body is probably more similar to terrestrial "soda lakes," such as Mono Lake in California, than it is to the Atlantic and Pacific oceans

#### **An energy source in the dark depths**

- This shouldn't dishearten astrobiologists; a variety of lifeforms thrive in Mono Lake, including brine shrimp and many different types of microbe.
- The new study provides other reasons to be optimistic about Enceladus' life-hosting potential.
- The team's model suggests that the subsurface ocean's high pH is generated by a process called serpentinization, in which certain kinds of metallic rocks from Enceladus' upper mantle are transformed into new minerals (including serpentine, hence the name) via interactions with water.
- In addition to raising pH, serpentinization results in the production of molecular hydrogen (H<sub>2</sub>) — a potential source of chemical energy for any lifeforms that may exist in the underground sea.
- "Molecular hydrogen can both drive the formation of organic compounds like amino acids that may lead to the origin of life, and serve as food for microbial life such as methane-producing organisms."
- As such, serpentinization provides a link between geological processes and biological processes.
- The discovery of serpentinization "makes Enceladus an even more promising candidate for a separate genesis of life."
- Sunlight doesn't reach Enceladus' underground sea, but any microbes that exist there may thus have access to two different sources metabolism-supporting energy sources — molecular hydrogen and the heat provided by hydrothermal vents. ##

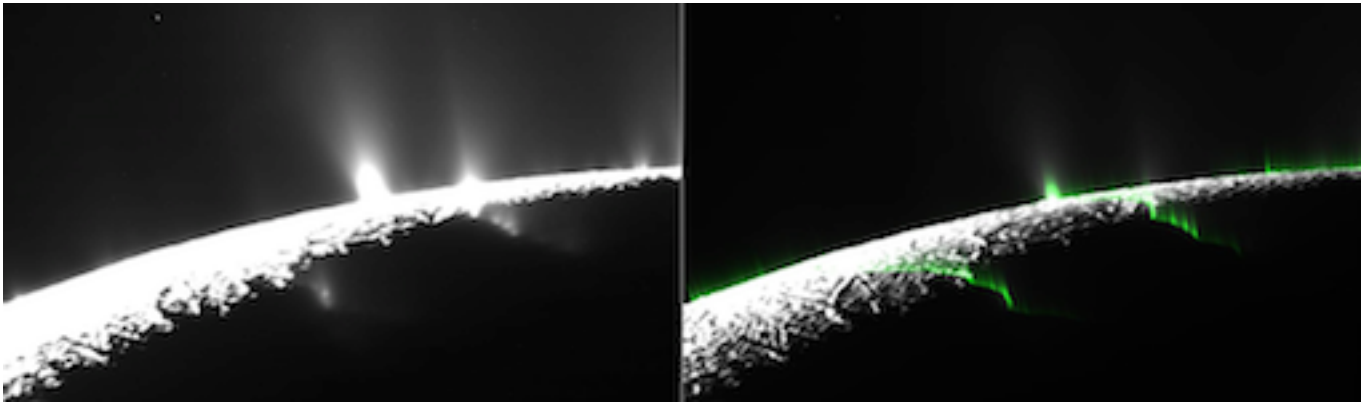
### **'Jets' on Enceladus May Actually Be Giant Walls of Vapor and Ice**

8 May, 2015 - [www.space.com/29330-saturn-moon-enceladus-geysers-curtains.html](http://www.space.com/29330-saturn-moon-enceladus-geysers-curtains.html)

[www.space.com/25350-enceladus-icy-saturn-moon-explained-infographic.html](http://www.space.com/25350-enceladus-icy-saturn-moon-explained-infographic.html)

[www.space.com/29331-saturn-moon-s-eruptions-are-curtain-like-new-research-suggests-video.html](http://www.space.com/29331-saturn-moon-s-eruptions-are-curtain-like-new-research-suggests-video.html)

**Curtains of vapor and ice miles high and hundreds of miles long might erupt from rifts on Saturn's icy, ocean-harboring moon Enceladus.**



New research suggests that much of the eruption activity near the south polar region of Saturn's moon Enceladus could be in the form of broad, curtain-like eruptions, rather than discrete jets.

- In fact, most of the seemingly discrete geysers seen on Enceladus until now may have just been optical illusions of these much broader "curtain" eruptions, the scientists said in the new study.
- Enceladus is Saturn's 6th-largest moon, a 500 km (310-mi) wide satellite coated with an icy shell.
- Years ago, Enceladus was seen as cold and geologically dead
- But in 2005, the Cassini spacecraft spotted water vapor and icy particles erupting from the moon.
- Scientists then determined that these outbursts originate from four "tiger stripes" — fractures on Enceladus' south pole, named after the cities Alexandria, Baghdad, Cairo and Damascus.
- These explosions are fed by a network of cracks that may carry water up from a subsurface ocean..
- Initially, planetary scientists s thought these eruptions were concentrated jets.
- But now, we've found that these explosions may actually be giant curtains of vapor and ice.
- What looked like jets were optical illusions — they were really curtains.
- Scientists analyzed these Cassini images in order to determine where these eruptions come from and what might cause them.
- It became evident that a lot of the tiny little jets we looked at were real slippery — we couldn't triangulate them. We also saw very broad areas of emissions that couldn't be jets — just huge fuzz.
- How could the "curtains" be mistaken for focused jets? The fractures from which the curtains emerge often meander, Instead of stretching in perfectly straight lines, they can fold against one another.
- In places where these curtains bunch up, eruptions of vapor and ice are denser, and esemble jets.
- This should have been obvious, but it was a big surprise.
- In five snapshots of Enceladus taken during a one-year period 2009 – 2010, most of the time, most of the fractures are turned ond. They're emitting at some level all the time.
- Enceladus may still have concentrated jets of vapor and ice.
- All of these eruptions may or may not be curtains. Jets might occur where fractures meet, or where debris falling into fractures has propped the cracks open, he suggested.
- Future research can see when these curtain eruptions grow or shrink in strength. Tidal forces may be influencing these eruptions — the gravitational pull of Saturn should be affecting the amount of stress on these fractures to open or close them. ##

## URANUS

## NEPTUNE



## PLUTO-CHARON & BEYOND

### What Would It Be Like to Live on Pluto?

31 March, 2015 - [www.space.com/28971-how-to-live-on-pluto.html](http://www.space.com/28971-how-to-live-on-pluto.html)

In 2006, Pluto lost its status as a planet when it was reclassified as a dwarf planet, a move that caused much controversy and debate. one thing is certain: The Pluto-Charon system is shrouded in mystery, and we don't have a complete picture of what it would be like to live there.

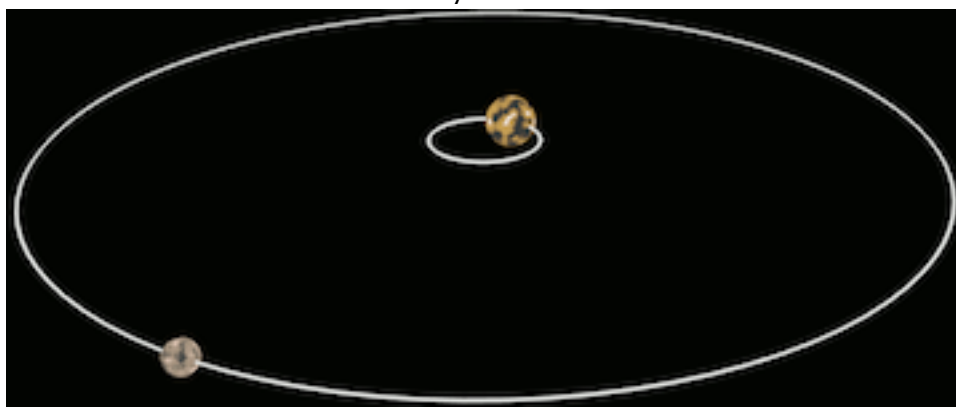
- NASA's New Horizons probe is the first to ever to visit Pluto, in a close flyby on July 14.
- We'll know a lot more about Pluto when New Horizons gets there.

#### If you lived on Pluto right now --

- It would take about 4.5 hours for your messages to reach the Earth-Moon system.
- The exact time delay it would take for such a message would vary greatly throughout Pluto's year (248 Earth years) as Pluto travels along a highly elliptical orbit that brings it inside Neptune's orbit for 20 Earth years; during this time, when Pluto is closes, a message sent home would take about four hours.
- When Pluto is farthest from Earth, that message would travel for over 6.5 hours.
- Depending on where it is in its orbit, you can expect freezing temperatures on Pluto that vary from  $-223\text{ }^{\circ}\text{C}$  ( $-369\text{ }^{\circ}\text{F}$ ) to  $-233\text{ }^{\circ}\text{C}$  ( $-387\text{ }^{\circ}\text{F}$ ). This shift in temperature may also affect Pluto's atmosphere.

#### "Winter" on Pluto

- When closer to the Sun, Pluto's surface ices sublimate into gas, creating a tenuous atmosphere.
- Computer models suggest atmospheric winds of 362 km/h (225 mph) and a surface pressure that's currently about 3 microbars (Earth's surface pressure is 1 bar)
- It's unknown what kind of weather patterns Pluto may have.
- We expect that Pluto's atmosphere virtually disappears when farthest from the sun as the atmosphere's gases transition back to ice.
- Photos from the Hubble Space Telescope show that the surface of Pluto has large differences in brightness, suggesting a varied landscape..
- Pluto is 2/3rds as wide as the Moon and has **about the same surface area as Russia**, by far the largest nation on Earth in area.
- Pluto's gravity is 1/15th of Earth's. 68 kg (150 lbs) on Earth would weigh 4.5 kg (10 lbs) on Pluto
- Pluto and its largest moon, Charon, are tidally locked – one side of Pluto and one side of Charon always face one another.
- If you were standing on the side of Pluto facing Charon, the moon would appear quite large. On Earth, you could blot out the Moon with your thumb if you held out your arm, but it would take almost your entire fist to block Charon while standing on Pluto.
- Pluto's next two largest moons, Nix and Hydra, would also be visible with your naked eye.
- Pluto's other known moons are Kerberos and Styx.



[http://upload.wikimedia.org/wikipedia/commons/6/6c/Pluto-Charon\\_System.gif](http://upload.wikimedia.org/wikipedia/commons/6/6c/Pluto-Charon_System.gif)

a video of Pluto and Charon in orbit around one another – do watch!

The distance between the two is 19,640 km (12,200 mi)



First color photo of the pair – note how much darker Charon is. The contrast may be due to a difference in composition of the two bodies, or caused by a previously unseen atmosphere on Charon. The photo also shows how much larger Charon is, compared to Pluto, than the Moon compared to Earth.

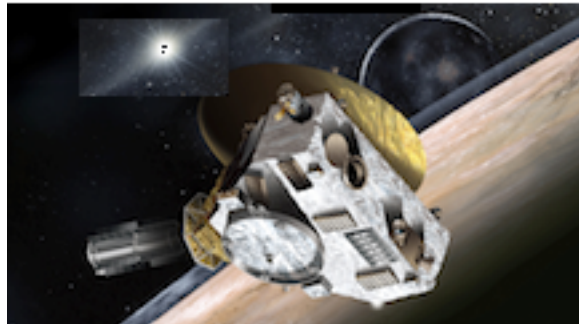
- The new photo, taken on April 9 from a distance of about 115 million km (71 million mi), is already revealing insights about Pluto and Charon. New Horizons flies by the Pluto system on July 14.
- Pluto is getting its first close-up decades after planets such as Venus, Mars and Neptune got theirs.
- The decades delay has allowed New Horizons to pack more advanced scientific instruments. ##

**Editor:** IF this distance between the two varies little enough, a cableway/double-anchored “Space Elevator” between Pluto and Charon should be quite feasible

- Pluto’s day is 6.4 Earth days
- From Pluto, the sun would look like Jupiter does from Earth — like a fat star — though much brighter.
- Whether there are environmental dangers like volcanoes or geysers, we don't yet know. ##

## Pluto Weather Forecast: Probe Likely to Find It Gusty and Gassy

7 April, 2015 – [www.space.com/29031-pluto-space-weather-new-horizons.html](http://www.space.com/29031-pluto-space-weather-new-horizons.html)



Wondering how the space weather will be around Pluto this summer?

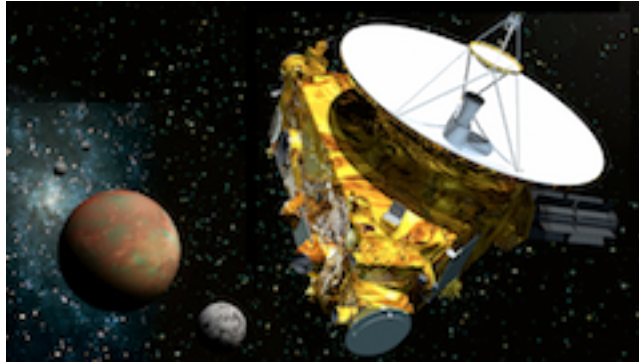
- Scientists working with NASA's New Horizons mission are predicting gusts of charged particles with speeds up to 1.6 million km/h (1 million mph) that will slow as they interact with Pluto's atmosphere.
- New Horizons will make a flyby of Pluto July 14, and has already been sampling the space weather environment in the Kuiper Belt, the ring of icy bodies beyond Neptune.
- Results from those measurements are being radioed to Earth, and we are already learning new things about the environment near Pluto's orbit, 4.8 billion km {3 billion mi} from Earth.
- While Pluto lies an average of more than 5.8 billion km {3.6 billion mi} from the Sun, Pluto, Charon, and their moons still feels the effects of the same solar wind that interacts with Earth's atmosphere.
- New Horizon's Solar Wind Around Pluto (SWAP) and Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI) instruments are helping us understand how that wind is behaving near Pluto.
- The solar wind — primarily protons and electrons, but also trace amounts of ionized helium and oxygen — surges outward at speeds of up to 500 km/sec (275 mi/sec).
- Near Pluto, the wind is spread thin, about 1,000 times less dense than near Earth, and a hundred billion billion times less dense than Earth's atmosphere at sea level..
- Pluto’s atmosphere is composed primarily of nitrogen, traces of carbon monoxide and methane.
- But Pluto's air is extremely thin, and slowly escaping into space over the eons.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- For an unknown reason, the sun has been blowing less hard over the past decade and a half, and we are seeing the weakest solar wind of the space age.
- A weaker solar wind means that the size of the region where the solar wind interacts with the planet's escaping atmosphere is expanded beyond our earlier predictions.
- This means that New Horizons may cross the interaction boundary between the solar wind and Pluto's atmosphere up to dozens of Pluto radii — and several hours — before its closest approach to the planet itself on July 14, creating a scientific bonanza for studies of the composition and escape rate of Pluto's atmosphere. ##

## Bulletproof Vest Shields NASA's Pluto-Bound Spacecraft (Exclusive Video)

9 April, 2015 – [www.space.com/29062-new-horizons-pluto-bulletproof-vest-video.html](http://www.space.com/29062-new-horizons-pluto-bulletproof-vest-video.html)



- New Horizons is the fastest spacecraft ever launched, traveling through space at 54,720 km/h (34,000 mph) - covering the distance from New York City to Los Angeles every 4 minutes or so.
- The probe has traveled more than 4.8 billion km (3 billion mi) since blasting off in January 2006
- Traveling at this breakneck speed, even a minor collision could be game over for the entire mission.
- That is why NASA's Pluto-bound New Horizons probe is wearing a bulletproof vest.
- So onboard computers and other systems are wrapped in a layer of Kevlar that should protect them from an encounter with a stray rock or a bit of debris.
- In this exclusive space.com video, New Horizons Principal Investigator Alan Stern talks about the dangers facing New Horizons as it nears Pluto,
- And the steps the mission can take to avoid catastrophe.##

## Is Pluto Really Red? Chemistry Says It Could Be | Video

[www.space.com/29101-is-pluto-really-red-chemistry-says-it-could-be-video.html](http://www.space.com/29101-is-pluto-really-red-chemistry-says-it-could-be-video.html)

Ground-based and Hubble images of Pluto suggest it might be the reddest object in the Solar System. New Horizons' Principal Investigator Alan Stern explains how this could have happened. ##

## Pluto-Charon's Moons Are Even Weirder Than Thought

3 June, 2015 – [www.space.com/29559-pluto-moons-weird-orbit-chaos.html](http://www.space.com/29559-pluto-moons-weird-orbit-chaos.html)

[www.space.com/29561-spuds-in-space-pluto-moon-s-weird-spin-animated-video.html](http://www.space.com/29561-spuds-in-space-pluto-moon-s-weird-spin-animated-video.html)

[www.nasa.gov/press-release/nasa-s-hubble-finds-pluto-s-moons-tumbling-in-absolute-chaos](http://www.nasa.gov/press-release/nasa-s-hubble-finds-pluto-s-moons-tumbling-in-absolute-chaos)

Pluto's moons are even stranger and more intriguing than scientists imagined.

The Pluto-Charon system consists of four tiny satellites — Nix, Hydra, Kerberos and Styx — orbiting a "binary planet" Pluto and Charon.

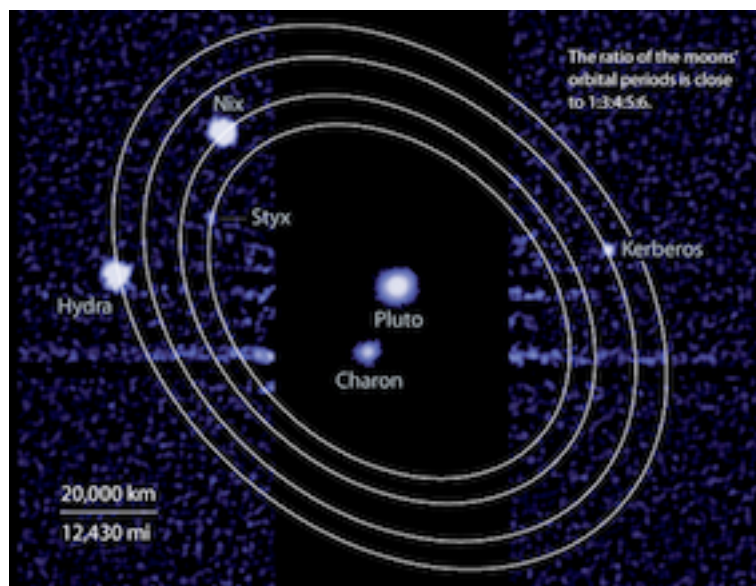
- This binary setup has profoundly influenced the orbits of the four small moons, injecting chaos into their movements — as depicted in a newly released animation of tumbling Nix — in ways not fully appreciated until now.
- "It's a very strange place to live in if you are orbiting a binary planet,

## Brightness and size

PLUTO'S MOONS:	CHARON	STYX	NIX	KERBEROS	HYDRA
Year of discovery	1978	2012	2005	2011	2005
Diameter	648 miles (1,043 kilometers)	6-15 mi (10-25 km)	31-62 mi (50-100 km)	8-21 mi (13-34 km)	31-62 mi (50-100 km)
Orbital period (Earth days)	6.4	20.2	24.9	32.2	38.2

Researchers analyzed images of the Pluto system taken by the Hubble Space Telescope 2005–2012.

- They used these photos — which captured brightness variations of the moons over time — and computer models to characterize the four small satellites and their orbits in unprecedented detail.
- They derived new brightness and size estimates for the moons.
- Nix and Hydra are likely about as bright as Charon, which reflects roughly 40% of the light that hits it.
- Previously, "we didn't really know how big Nix and Hydra were, because we didn't know how bright they were. Now, we actually do pretty well know how big and how bright they are, so a lot of uncertainties about the properties of Nix and Hydra that have now vanished.
- Hubble images suggest that Hydra is c.45.4 km (28.2 mi) across, Nix c. 39.6 km (24.6 mi) or so.
- Kerberos and Styx, meanwhile, are probably about 24.8 km (15.4 mi) and 6.8 km (4.2 mi) wide.
- Most if not all of the four tiny satellites are probably ellipsoidal, not spherical.
- Kerberos is much darker than its fellow satellites, with a reflectivity of just 4 percent.
- Nix and Hydra are basically "dirty snowballs" in terms of reflectivity, "Kerberos is a charcoal briquet."
- We assumed that the moons would be pretty similar, formed at the same time of the same stuff.
- Pluto's four small moons were likely formed from the debris scattered by a long-ago giant impact between a proto-Pluto object and a proto-Charon, a very dark body.
- Kerberos is likely a relatively pristine piece of this original impactor
- Styx, Nix and Hydra are linked by a "resonance," a sort of gravitational sweet spot in which orbits of multiple celestial bodies are related by a ratio of two whole numbers.
- A similar three-body resonance is found among the Jupiter moons Io, Europa and Ganymede.
- The resonant relationship between Nix, Styx and Hydra makes their orbits more regular and predictable, and prevents them from crashing into one another



- There is also quite a bit of chaos in the Pluto system, imparted by **the complex and shifting gravitational field of the Pluto-Charon binary.**



- Nix and Hydra exhibit chaotic rather than synchronous rotation, meaning they don't always keep the same side facing Pluto–Charon — and it's very tough to predict their rotational movement. (Nearly every other moon in the solar system, including Earth's, is a synchronous rotator.)
- "If you lived on Nix, You'd have days where the sun rises in the east and sets in the north."
- Such findings could help researchers better understand the many alien planets that orbit binary stars.
- **Chaos may be a common trait of binary systems.**
- **This chaos might even have consequences for life on planets orbiting binary stars.**

#### **New Horizons and beyond**

- On July 14, NASA's New Horizons will zoom within 12,500 km (7,800 mi) of the Pluto's surface.
- New Horizons should get good looks at the surfaces of Nix and Hydra, and the probe's observations will likely reveal how dark Kerberos is.
- Data from the flyby, as well as continued long-term monitoring by Hubble and NASA's James Webb Space Telescope, which is scheduled to launch in 2018, could end up bringing Pluto's moons into sharp focus.
- Eventually we'll get a whole formation scenario for the Pluto–Charon system. ##

### **Pluto–Charon Probe May Carry Crowdsourced Message to “Aliens”**

19 May, 2015 – [www.space.com/29439-pluto-spacecraft-message-to-aliens.html](http://www.space.com/29439-pluto-spacecraft-message-to-aliens.html)

A NASA Pluto probe may end up with one final mission after its work exploring the outer solar system is done — carrying a message to advanced alien civilizations. **No, no messages aboard, not yet!**

#### **“Messages in a Bottle”**

- NASA is considering allowing a team of researchers, teachers, artists and engineers to **upload an interstellar message** to the New Horizon spacecraft.
- This project, known as the **“One Earth Message”**, is being led by Jon Lomberg, design director for the “golden records” that were placed aboard NASA's twin Voyager spacecraft before their 1977 launch to teach any aliens that might encounter the probes about humanity and its home planet,
- One Earth Message would have people around the world contributing images, sounds and ideas
- “We'll never know if this extraterrestrial audience that we're designing it for will receive it. But for the people of Earth who participate, who play a role in it — it can literally change their lives.”

#### **A digital message**

- The two Voyager probes' golden records are actual records — 30 cm (12-in) wide gold-plated copper disks that come with cartridges, needles and instructions about how to play them. The identical records contain 115 analog-encoded images, as well as audio of thunder and other natural sounds, music and spoken greetings in 55 different languages.
- The One Earth Message, by contrast, would be digital.
- NASA has expressed enthusiasm but has yet to approve it officially
- The team will be allowed to beam 150 megabytes of data to New Horizons.
- The One Earth Message would hold about the same amount of information as Voyager's golden records — 100 images and about an hour of audio, Lomberg said. (Videos take up too much memory.)
- The digital format would allow the One Earth Message to be more flexible, layered and integrated than was possible with the golden records
- For example, the message could be changed over time by beaming more files to New Horizons.
- It could also include a map of the world, and every picture and every sound could be tagged to the spot from which it came.

#### **Crowdsourced content and funding**

- Another key difference between the Voyager and New Horizons efforts: the One Earth Message would be a crowdsourced affair, with contributions from people around the globe.
- Just as the One Earth Message's content would be crowdsourced, a chunk of its funding would be too. (NASA would not pay for the project.)
- The hope is to raise at least \$500,000 from people around the world, to build and maintain a Web presence and to figure out the best way to program the message.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- Additional money raised would be used for education and outreach, among other things.
  - The total budget is a couple of million dollars, to do everything we'd like to do.
  - People would be able to contribute a set number of photos for possible inclusion for free
  - Anyone who wants to submit additional pictures would be able to do so, for a fee that would help cover the costs of the project's website.
  - The One Earth Message Fiat Physica campaign runs through July 15.
  - As of May 17 (2015), the effort had raised about \$12,000 of its \$500,000 target.
  - You can learn more about the campaign here: [www.fiatphysica.com/campaigns/oem/](http://www.fiatphysica.com/campaigns/oem/)
  - Drawing up a message designed to be understood by alien civilizations is not a simple or straightforward task. For example, how would any hypothetical extraterrestrials that chance upon New Horizons even know that humanity is trying to say something to them?
- Our challenge is to find ways to code the message so that it calls attention to itself as a message.**
- How can you send files so that aliens can figure them out? They're not going to know what a jpeg is.
  - **The transmission to New Horizons would occur in July 2016 at the earliest**, and it could even be postponed until after the probe flies by a second faraway object in 2019 during.
  - While the One Earth Message is designed to be interpreted by aliens, it's a worthwhile exercise even if no aliens ever find it. **The project has the potential to get people more excited about the New Horizons mission and space exploration in general — and possibly to bring people around the world together in a perspective-altering experience. ##**

## NASA Announces Television Coverage, Media Activities for Pluto Flyby

[www.nasa.gov/press-release/nasa-announces-television-coverage-media-activities-for-pluto-flyby](http://www.nasa.gov/press-release/nasa-announces-television-coverage-media-activities-for-pluto-flyby)



NASA artist's illustration of New Horizons skimming over Pluto's surface

NASA is inviting media to cover New Horizons' historic Pluto flyby in mid-July, including the spacecraft's closest approach to Pluto on July 14, from the Johns Hopkins University Applied Physics Laboratory (APL) in Laurel, Maryland, site of the mission operations center.

Media who wish to cover the events at APL must receive accreditation from the APL Public Affairs Office by June 30. Earlier registration is strongly encouraged, as space is very limited. To apply, and for more information, visit:

<http://pluto.jhuapl.edu/News-Center/Media-Registration.php>

NASA also will provide comprehensive coverage on NASA Television, and the agency's website and social media accounts as the spacecraft closes in on Pluto in the coming weeks.

The schedule for event coverage is subject to change, with daily updates posted online and in the New Horizons Media Center at APL. Highlights of the current schedule, all times EDT, include:

**July 7- 12 11:30 a.m. -- Final approach to Pluto; live daily mission updates on NASA TV**

**July 12 1 - 5 p.m. -- New Horizons Media Center opens at APL**

**July 13 11 a.m. - noon -- Media briefing: Mission Status and What to Expect. (live on NASA TV)**

**2:30 – 5:30 p.m.** -- Panels: APL's Endeavors in Space; the latest on New Horizons (no NASA TV coverage)

**July 14 7:30 a.m. – Media Briefing: Arrival at Pluto, Inside the Pluto System and New Horizons' Perilous Path (live)**

At 7:49 a.m., the New Horizons spacecraft will make history as flies past Pluto, after a journey of more than nine years and 3 billion miles. For much of the day the New Horizons spacecraft will be out of communication with mission control as it gathers data on Pluto and its moons.

The moment of closest approach will be marked with a live NASA TV broadcast that includes a countdown, a discussion of images and data received thus far, and what's expected next as New Horizons makes its way past Pluto and potentially dangerous debris. Follow the path of the spacecraft in real time with a visualization of the actual trajectory data, using NASA's Eyes on Pluto.

**9 a.m. – noon** -- Interview Opportunities (no NASA TV coverage)

Informal group briefings and availability for one-on-one interviews. An updated schedule will be posted in the New Horizons Media Center.

**Noon – 3 p.m.** – Panel Discussions (no NASA TV coverage)

- New Horizons mission overview and history
- Pluto system discoveries on approach
- Mariner 4 and Pluto: 50 years to the day

**8 – 9:15 p.m.** -- NASA TV program, Phone Home, broadcast from APL Mission Control

NASA TV will share the suspenseful moments of this historic event with the public and museums around the world. The New Horizons spacecraft will send a preprogrammed signal after the close approach. The mission team should receive the signal at about 9:02 p.m. When New Horizons "phones home," there will be a celebration of its success and anticipation of data to come in days, months ahead.

**9:15 – 10 p.m.** -- Media Briefing: New Horizons Health and Mission Status (live on NASA TV)

**July 15**

**Noon – 3 p.m.** -- Interview Opportunities (no NASA TV coverage)

Informal group briefings and availability for one-on-one interviews. An updated schedule will be posted in the New Horizons Media Center.

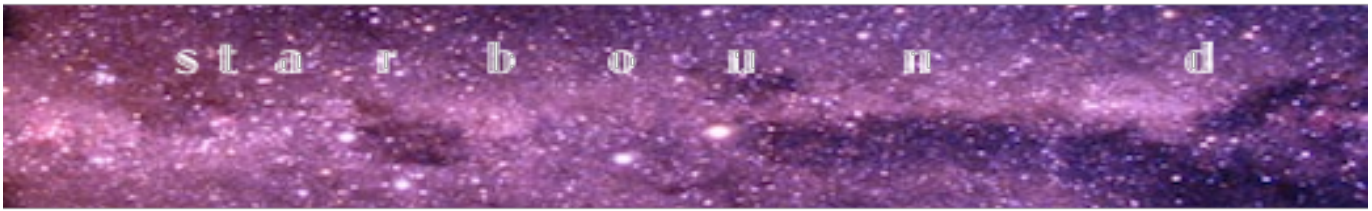
**TBD** -- Media Briefing: Seeing Pluto in a New Light (live on NASA TV) Release of close-up images of Pluto's surface and moons, along with initial science team reactions

New Horizons is the first mission to the Kuiper Belt, a gigantic zone of icy bodies and mysterious small objects orbiting beyond Neptune. This region also is known as the "third" zone of our solar system, beyond the inner rocky planets and outer gas giants.

APL designed, built and operates the New Horizons spacecraft, and manages the mission for NASA's Science Mission Directorate in Washington. The Southwest Research Institute in San Antonio leads the science team, payload operations and encounter science planning. New Horizons is part of the New Frontiers Program, managed by NASA's Marshall Space Flight Center in Huntsville, Alabama.

More information on New Horizons mission: fact sheets, schedules, video and images, visit:

- <http://www.nasa.gov/newhorizons> or
- <http://solarsystem.nasa.gov/planets/plutotoolkit.cfm>



[The articles below have been summarized by the editor. For the full text, see the links cited.]

## OUR CLOSEST STAR: THE SUN

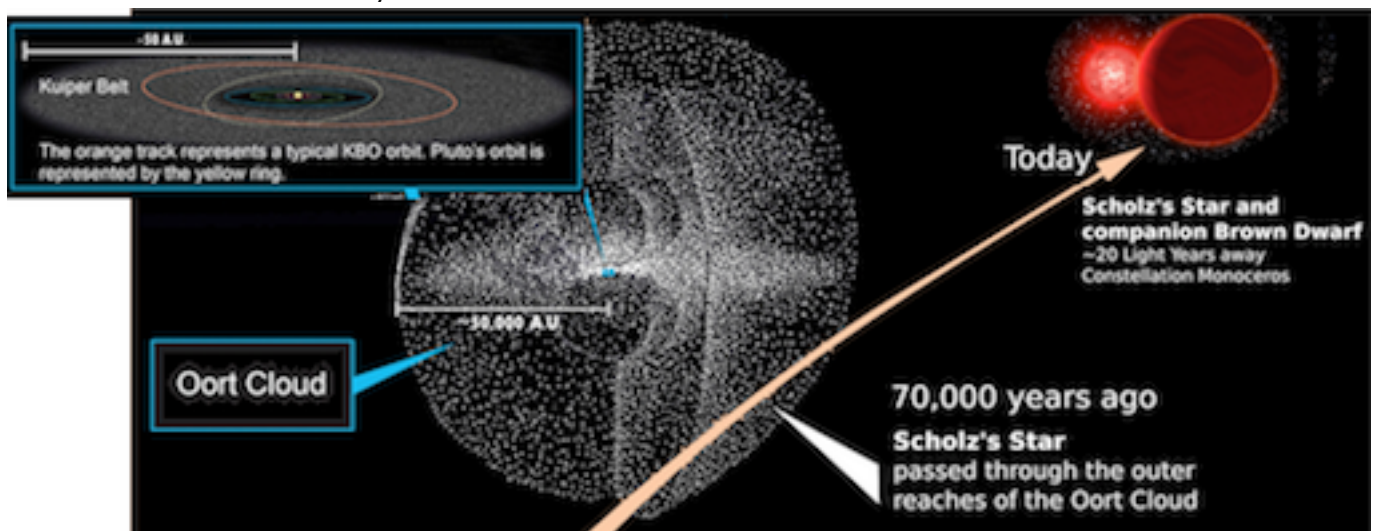
### A Star Passed Through the Solar System Just 70,000 Years Ago

[www.universetoday.com/119038/a-star-passed-through-the-solar-system-just-70000-years-ago/](http://www.universetoday.com/119038/a-star-passed-through-the-solar-system-just-70000-years-ago/)

15 February, 2015 (story previously missed) –

Astronomers have reported discovery of a star that passed within the outer reaches of our Solar System just 70,000 years ago, when early humans were beginning to take a foothold here on Earth.

- The stellar flyby was likely close enough to have influenced the orbits of comets in the outer Oort Cloud, but our early ancestors were not in danger.
- Now astronomers are ready to look for more stars like this one.



A comparison of the Solar System and its Oort Cloud. 70,000 years ago.

Scholz's Star and companion passed along the outer boundaries of our Solar System

(Credit: NASA, Michael Osadciw/University of Rochester, Illustration–T.Reyes)

- Lead author Eric Mamajek from the University of Rochester and collaborators report in [The Closest Known Flyby Of A Star To The Solar System](#) (published in *Astrophysical Journal* on February 12, 2015) that “the flyby of this system likely caused negligible impact on the flux of long-period comets
- The recent discovery of this binary suggests that other Oort Cloud perturbers may be nearby.
- “Scholz's star” was just 9.7 light months away at closest approach to the Sun, a fifth of the distance to Proxima Centauri (4.2 light years) now the closest star.
- Unlike the suggestion of a Nemesis star that is approaching the inner Solar System, this small red dwarf star with a companion was the real thing.
- In 1984, the paleontologists David Raup and Jack Sepkoski postulated that a dim dwarf star, now widely known on the internet as the Nemesis Star, was in a very long period Solar orbit. Recent studies of impact rates on Earth, the Moon and Mars have discounted the existence of a Nemesis star.
- But Scholz's star — a real-life Oort Cloud perturber — was a small red dwarf star with a M9 spectral classification. M-class stars are the most common star in our galaxy and likely the whole Universe, as 75% of all stars are of this type.
- Scholz's Star is just 15% of the mass of our Sun.



- Scholz's is a binary star system with the secondary being a brown dwarf of class T5.
- Brown Dwarfs are believed to be plentiful in the Universe but due to their very low intrinsic brightness, they are very difficult to discover ... except, as in this case, as companions to brighter stars.  
[The editor calculates that on the basis of brown dwarf abundance, there should be at least one closer to the Sun than Proxima Centauri, but still awaiting discovery.]

#### Astronomers has identified Scholz's as an object of interest.

- ✓ The star's transverse velocity was very low, that is, the stars sideways motion.
- ✓ Additionally, its radial velocity - motion towards or away from us, is quite high.
- ✓ Scholz's star is speeding **directly away** from our Solar System.
- ✓ How close could Scholz's star have been to our system in the past?

The collaborators used two large telescopes in the southern hemisphere.

- Spectrographs were employed on the Southern African Large Telescope (SALT) in South Africa and the Magellan telescope at Las Campanas Observatory, Chile.
- With more accurate tangential and radial velocities, the researchers were able to calculate the trajectory, accounting for the Sun's and Scholz's motion around the Milky Way galaxy.
- Scholz's star is an active star and the researchers added that while it was nearby, it shined at a dimly of about 11th magnitude but eruptions and flares on its surface could have raised its brightness to visible levels and could have been seen as a "new" star by primitive humans of the time.
- At present, Scholz's star is 20 light years away, one of the 70 closest stars to our Solar System.
- However, the astronomers calculated, with a 98% certainty, that Scholz's passed within 0.5 light years, approximately 50,000 Astronomical Units (A.U.) of the Sun.
- With this first extraordinary close encounter discovered, the collaborators of this paper as well as other researchers are planning new searches for "Nemesis" type stars.
- The Large Synoptic Survey Telescope (LSST) and other telescopes within the next decade will bring an incredible array of data sets that **will uncover many more red dwarf, brown dwarf and possibly orphan planets roaming in nearby space.**
- Some of these could likewise be traced to past or future near misses to the Sun and Earth system. ##

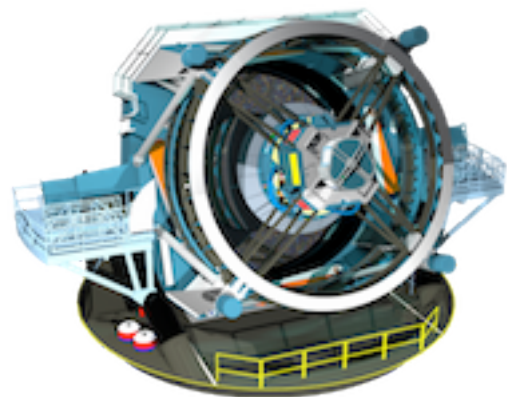
**Editor:** Most writers fail to realize that in a close pass by a more massive star, our solar system may have passed **through that star's Oort Cloud**, a far more likely case than such a star knocking objects in our Oort cloud into the inner solar system (reducing their orbital velocity perpendicular to the Sun to near zero, a mathematical miracle. ##

## EARTHBOUND TELESCOPES

### LSST – Large Synoptic Survey Telescope – lays first stone

15 April, 2015 – <http://phys.org/news/2015-04-lsst-stone.html>

A new ground-based telescope promises unprecedented information about distant galaxies, nearby asteroids and even the mysterious dark energy that is accelerating the expansion of our universe.



This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

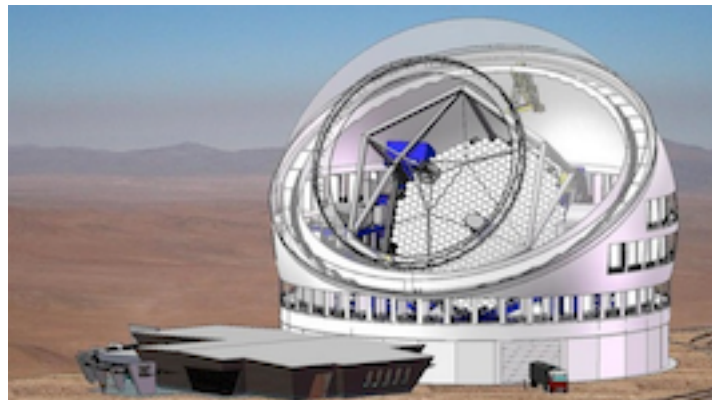
and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

View of the **Large Synoptic Survey Telescope's** exterior building, from the road leading up to the site, a mountain peak in northern Chile called Cerro Pachon. The LSST will be an 8-meter wide-field survey telescope that will image the entire visible sky a few times each week for 10 years. (note size of car for size comparison)

- Collaborators from the U.S. National Science Foundation (NSF), U.S. Dept .of Energy (DOE), Chile's Ministry of Foreign Affairs and Comisión Nacional de Investigación Científica y Tecnológica (CONICYT) and several other international public-private partners gathered outside La Serena, Chile, for a traditional Chilean stone-laying ceremony to celebrate the construction launch of the LSST.
- LSST will be an 8-m (310") wide-field survey telescope that will image the entire visible sky a few times each week for 10 years, providing an unprecedented amount of information while transforming the emerging discipline of data-enabled science. I
- The telescope is expected to see first light in 2019 and begin full operation in 2022.
- Equipped with a 3-billion pixel digital camera (world's largest), LSST will observe objects as they change or move, providing insight into short-lived transient events such as astronomical explosions and the orbital paths of potentially hazardous asteroids.
- LSST will take more than 800 panoramic images of the sky each night, allowing for detailed **maps of the Milky Way** and of **our own solar system** and **charting billions of remote galaxies**. Its observations will also **probe the imprints of dark matter and dark energy** on the evolution of the universe.
- NSF and DOE will share responsibilities over the lifetime of the project.
  - The NSF, through its partnership with the Association of Universities for Research in Astronomy (AURA), will develop the site and telescope, along with the extensive data management system, as well as coordinate education and outreach efforts.
  - DOE, through a collaboration led by its SLAC National Accelerator Laboratory, will develop the large-format camera.
- Chile will serve as project host, providing (and protecting) access to some of the darkest and clearest skies in the world over the LSST site on Cerro Pachón, a mountain peak in northern Chile.
- The site was chosen through an international competition due to the pristine skies, low levels of light pollution, dry climate and the robust and reliable infrastructure available in Chile.
- Data sets will be immediately available to scientists and the general public.
- Tens of thousands of transient events each night will be available to the entire world: social networks, citizen scientists, and students everywhere.
- The NSB voted to approve the LSST project in August 2012, clearing the way for NSF to include funds for construction in NSF's annual budget request.
- Private donors, including the Charles and Lisa Simonyi Fund for Arts and Sciences, and Bill Gates played a critical role in supporting LSST construction.
- A complete list of LSST institutional members is online. ##

## 30 Meter Telescope opposition by Native Hawaiians

[www.scientificamerican.com/article/world-s-largest-telescope-faces-opposition-from-native-hawaiian-protesters/](http://www.scientificamerican.com/article/world-s-largest-telescope-faces-opposition-from-native-hawaiian-protesters/)



[Note: Science Magazine articles are available to subscribers only.  
What follows is a synopsis that the magazine makes publicly available..]

"In Hawaii, work on what would be one of the world's largest optical telescopes has been halted by protests by Native Hawaiian groups, who claim that building the Thirty Meter Telescope (TMT) on the slopes of Mauna Kea, on Hawaii's Big Island, would desecrate a sacred site.

But the \$1.2 billion project, led by an international consortium based in Pasadena, California, has also become embroiled in a long-running dispute over Hawaiian sovereignty. "It comes down to the fact that there is an occupation of Hawaii by the United States."

Native groups say state officials had no right to issue permits for the project in March and say that research groups have mismanaged the mountain's summit, which is already home to 13 telescopes. The dispute took a new turn on 30 April, when a state board that advocates for Native Hawaiians voted to rescind its earlier endorsement of the project. But the board rejected calls to oppose construction of the telescope outright, saying it wanted to retain a more neutral position in continuing negotiations over the TMT's fate." ##

### Construction of Giant Telescope Pushes on Despite Protests

22 June, 2015 - [/www.space.com/29729-thirty-meter-telescope-construction-restart.html](http://www.space.com/29729-thirty-meter-telescope-construction-restart.html)

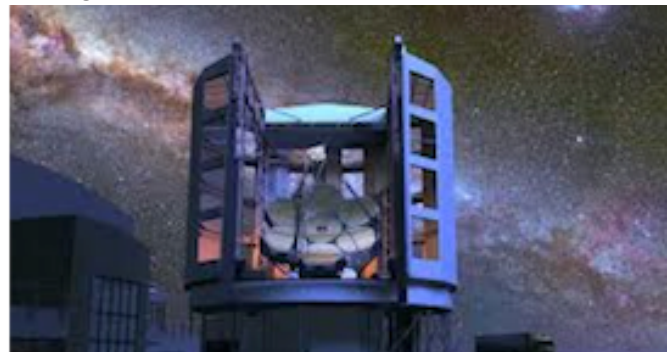
Construction to be resumed on June 24, ending a two-month delay caused by protestors opposed to the ambitious project.

"Our period of inactivity has made us a better organization in the long run. We are now comfortable that we can be better stewards and better neighbors during our temporary and limited use of this precious land, which will allow us to explore the heavens and broaden the boundaries of science in the interest of humanity." - TMT International Observatory Board.

### Giant Magellan Telescope gets green light for construction

[news.sciencemag.org/funding/2015/06/giant-magellan-telescope-gets-green-light-construction](http://news.sciencemag.org/funding/2015/06/giant-magellan-telescope-gets-green-light-construction)

4 June, 2015 - The Giant Magellan Telescope (GMT), the third of a trio of megatelescopes that will peer skyward next decade, yesterday received \$500 million to begin construction.



- GMT will ultimately cost about \$1 billion, will have a mirror 25 meters across, giving it vision 10 times sharper than the Hubble Space Telescope.
- The funding agreement means that work can begin soon on the observatory structure at Las Campanas in northern Chile and on the instrument itself.
- The telescope, set to be fully operational by 2024, is backed by 11 institutions in Australia, Brazil, Chile, Korea, and the United States.
- GMT will reveal the first objects to emit light in the universe, explore the mysteries of dark energy and dark matter, and identify potentially habitable planets in the Earth's galactic neighborhood."
- Advances in optics mean that next generation telescopes will be much bigger. The European Southern Observatory has begun construction of its European Extremely Large Telescope (E-ELT) with a 39-meter mirror at Cerro Armazones in northern Chile, and a group of institutions from China, India, Japan, and the United States has started building the 30 meter telescope (TMT) at Mauna Kea in Hawaii. TMT construction was recently halted following protests by indigenous Hawaiians, and efforts are continuing to find a compromise.

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and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



- The GMT, which is the smallest of the three, uses a different mirror technology. Its main reflector is made up of seven large mirrors, each one 8.4 meters across with a weight of 17 tons.
- The other two scopes use a segmented mirror approach, their reflectors patched together with a much larger number of hexagonal mirror tiles (798 on the E-ELT and 492 on the TMT), each one independently steerable.
- This new generation of telescopes will allow huge advances in studies of the early universe, of Earth-like planets around other stars, and of the mysterious dark matter and dark energy that influence the structure and expansion of the universe. ##

## STARBOUND TELESCOPES

### SETI Has New Infrared Telescope Tech in Search for E.T.

31 March, 2015 - [www.space.com/28910-seti-infrared-telescope-tech-nirosetti.html](http://www.space.com/28910-seti-infrared-telescope-tech-nirosetti.html)



**Left:** U. of California's Lick Observatory an NIROSETI telescope instrument to search for signs of intelligent extraterrestrial civilizations by scanning for messages in infrared light.

**Center & Right:** The near-infrared optical SETI new infrared detector inside the dome at Lick Observatory.

- Scientists searching for signs of intelligent extraterrestrial life in the universe have a new telescope tool to aid them in their hunt for potential alien civilizations.
- **NIROSETI**, short for **Near-Infrared Optical Search for ExtraTerrestrial Intelligence**, the instrument saw its "first light" this month at the U. of California's **Lick Observatory** Mt. Hamilton east of San Jose.
- It can record levels of light over time so that patterns can be analyzed for potential signs of alien life.
- For more than 50 years, scientists have been on the lookout for radio signals from other starfolk.
- But instruments capable of capturing pulses of infrared light have only recently become available.
- The NIROSETI instrument has months of fine-tuning to follow its first-light observation on March 15.
- **Infrared light penetrates farther through gas and dust than visible light.**
- This new search will extend **to stars thousands rather than merely hundreds of light-years away.**
- NIROSETI could uncover new information about the physical universe as well.- as well as [help](#) shape an answer to some big questions: Are we alone? Just how crowded is it out there?
- Regarding use of NIROSETI there is one downside, according to Drake. "The extraterrestrials would need to be transmitting their signals in our direction. ##

**Editor:** **It is cheap to listen, expensive to send signals in all directions. To increase the chances of "being heard, the sending civilization must broadcast in all directions, continually, over the length of its existence - a "cathedral building endeavor." In other words, no one is sending unless they are a messianic culture bent on interfering with the natural development of more primitive cultures - going against Star Trek's "Prime Directive" not to interfere with the natural growth and development of civilizations. Pk**



## Beyond Hubble: Will Future Space Telescope Seek Alien Life by 2030?

15 April, 2015 - [www.space.com/29114-hubble-space-telescope-successor-alien-life.html](http://www.space.com/29114-hubble-space-telescope-successor-alien-life.html)



The famed Hubble Telescope, turn 25 this month

- Getting the ball rolling on a life-hunting successor instrument would be a fitting birthday present.
- Hubble, a joint NASA/ESA project, blasted off aboard the space shuttle Discovery on April 24, 1990.
- Astronauts fixed a serious problem with the telescope's optics in 1993, and Hubble has been transforming our understanding of the cosmos — and bringing us gorgeous images — ever since.
- Hubble will likely be able to keep studying the heavens for at least five more years, but it's now time to plan/design/build a future space telescope that will tackle the next big frontier in space science— **the search for signs of life beyond our neighborhood in space.**
- Hubble's successor is NASA's \$8.8 billion James Webb Space Telescope (JWST), due to launch in 2018.
- The infrared-optimized JWST will be able to study the atmospheres of some nearby planets discovered by the Transiting Exoplanet Survey Satellite, or TESS, which NASA aims to launch in 2017.
- NASA is also developing a potential space-telescope mission called WFIRST/AFTA (Wide Field Infra-red Survey Telescope-Astrophysics Focused Telescope Assets), which could launch around 2024
- It would continue the hunt for biosignatures, and several other major tasks.

### Something even more ambitious: are Earthlike planets rare or common?

- A space telescope primary mirror at least 12 m (39 ft/472") wide, 25 times sharper than Hubble.
- Such a powerful instrument could scan the skies of enough "Earthlike" exoplanets to put "meaningful statistical constraints" on the abundance or rarity of alien life throughout the Milky Way galaxy.
- A large sample of planets — say 50 — would have to be tested.
- For example, if no biosignatures are detected in more than about three dozen Earth analogues, the probability of remotely detectable extrasolar life in our galactic neighborhood is less than say 10 %
- The Association of Universities for Research in Astronomy may release a report this June,
- NASA, ESA and other potential international partners should convene to examine such a project,
- Technology-development studies should be accelerated to make a launch around 2030 plausible.
- The search for life must be prioritized in the next international decadal surveys .
- Many scientists would agree that the question of, 'Is there extrasolar life?' is one of the most intriguing questions in science today.
- We hope to actually answer that question, as opposed to maybe taking baby steps that would just push the answer into the more distant future. ##

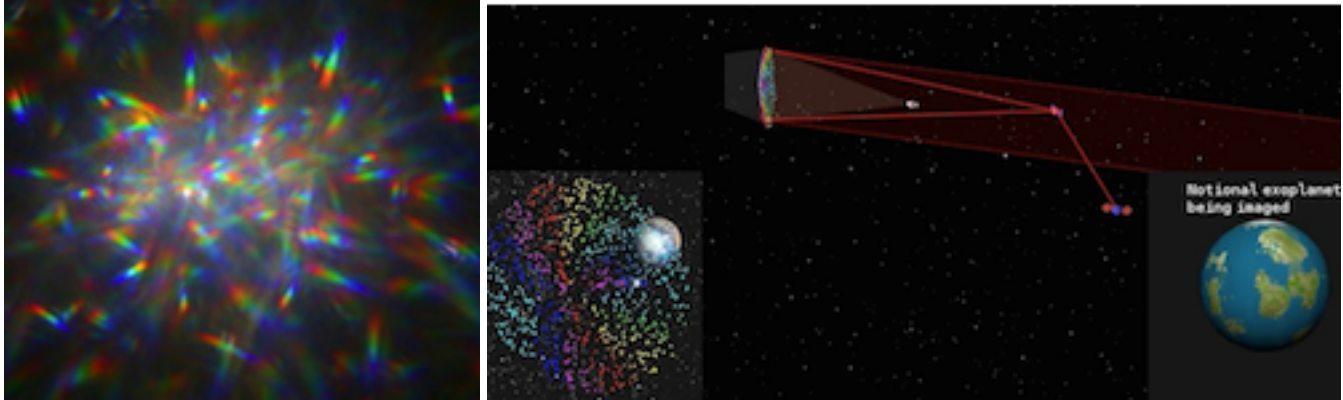
## 'Floating Cloud' Could Replace Mirrors on Future Space Telescopes

16 June, 2015 - [www.space.com/29677-floating-cloud-space-telescope-glitter-tech.html](http://www.space.com/29677-floating-cloud-space-telescope-glitter-tech.html)

Using clouds of glitter to reflect light could reduce the weight of future space telescopes.

- The "Orbiting Rainbows" technology would cause particles to behave like a floating mirror, which would be much lighter than the solid mirror typically placed in a telescope.

- The lighter "mirror" would require less fuel to send telescopes into orbit, thus reducing the cost.
- The floating cloud has no backing structure, no steel around it, no hinges; just a cloud.



**Left:** Image of laser light reflected off a glitter mirror onto a camera sensor.

**Right:** This NASA graphic shows how a glitter cloud in geostationary orbit could be illuminated and controlled by lasers to serve as a giant space telescope mirror to spot exoplanets. The project concept is known as the "Orbiting Rainbows."

- The system, still under development at JPL, would move and trap a cloud of millions of "glitterlike grains" with several laser beams. The photons of light in the laser beam would push at the cloud from different directions, aiming to align the grains in the same direction.
- The Orbiting Rainbows system could have a larger aperture — the spot where light passes through — than conventional telescopes.
- The trade-off is image distortion, as mirrors are more finely honed to reflect light than a glitter cloud.
- To get around this, researchers are working on computer algorithms that would examine several images and remove the "speckle effect" the glitter creates.
- So far, the idea has been tested in the laboratory by spreading glitter on a conventional concave lens.
- The Orbiting Rainbows technology might be most successfully used for **radio telescopes** because the wavelength they use is so much longer — one centimeter for radio as opposed to nanometers for visible light. This means the grains don't have to be as precisely oriented to get a clear image.
- The technology could also be repurposed for applications such as earthquake detection.
- A laser-trapped mirror was first proposed in 1979 by French astronomer Antoine Labeyrie.
- Before deciding on the current design, the team also considered basing the novel technology on common light-scattering structures found in nature, like rainbows, clouds and comet tails.
- The technology is funded under NASA'S Innovative Advanced Concepts program — a division for new technologies that could be used in far-off future missions — and selected for Phase 2 funding in 2014.
- If the technology is ever tested in low-Earth orbit, the researchers plan to send up a telescope with only a small cloud of particles that would be about the size of a bottle cap.
- If light reflections are successful, they would then attempt imaging. ##

## EXO-PLANETS

### Mystery of Gas Giant Planets' Death Spiral May Be Solved

1 April, 2015 – [www.space.com/28991-gas-giant-planets-migration-mystery.html](http://www.space.com/28991-gas-giant-planets-migration-mystery.html)

- Material falling onto the core of a growing gas giant may provide the push needed to keep the new-born planet from spiraling into its star.
- The new discovery could solve the mystery of how gas giants like Jupiter survive the formation period.
- Heat from the falling material can create a force that pushes the evolving planet away from its sun.
- Embryo planets can either migrate outward as they form or stay near the orbit where they are forming, instead of migrating inward and ending on an orbit very close to the star.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

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Gas giants must form a massive core before they can begin accreting gas, but how the process works has been a mystery for more than three decades.

### Heating things up

- The widely accepted model of gas-giant formation calls for a solid core to form from a disk of gas and dust orbiting a new star.
- In the crowded system, the young core constantly adds material from the disk around it
- If this core grows fast enough, it can become massive enough to accrete gas and build a gas-giant planet before the gas dissipates over the first 10 million years of the disk's life.
- The long-acknowledged problem is that the growing core creates ripples in the disk that should cause it to spiral inward faster than it can grow.
- Cores may reach a stable orbit in the early solar system as super Earth planets, or spiral into the star.
- Now scientists developed a simulation that revealed a new twist that could keep growing gas-giant cores from migrating inward in a death spiral.
- As material from the disk falls toward the core, it releases heat. If this material strikes the core's surface, the crash produces heat, radiating energy away from the planet.
- This heat transfers to the gas near the planet.
- Due to the planet's rotation and the flow of the gas in the disk in orbit around the star, lobes of heated material form in front of and behind the young core.
- The heat causes both lobes to expand, becoming less dense, the trailing region receives more heat,
- As a result, the growing embryo is pulled more forward than backward along its orbital path, creating a "heating torque" that ultimately pushes the young embryo outward, away from its sun.
- How much the growing planet is pushed outward depends on the disk itself.
- The amount of solid material in a disk depends on how many elements heavier than helium are present — a characteristic called 'metallicity.' ##

## Guiding Our Search for Life on Other Earths

7 April, 2015 – [www.space.com/29028-alien-life-search-other-earths.html](http://www.space.com/29028-alien-life-search-other-earths.html)

A telescope will soon allow us to probe the atmosphere of Earthlike exoplanets for signs of life.

- Astronomers are modeling the atmospheric fingerprints for hundreds of potential alien worlds.
- The James Webb Space Telescope set to launch in 2018, with its 6.5 m (256") mirror, will be large enough to detect potential biosignatures in the atmosphere of Earthlike planets orbiting nearby stars.
- We may soon find a treasure-trove of such worlds.
- The forthcoming exoplanet hunter TESS (Transiting Exoplanet Survey Satellite), to launch in 2017, will scout the entire sky for planetary systems close to ours.
- The current Kepler mission focuses on more distant stars, 600–3,000 light-years from Earth.
- TESS will allow for the brief detection of thousands of new planets
- The James Webb will follow up on select candidates and their atmospheric composition.
- The work will require a lot of telescope time.

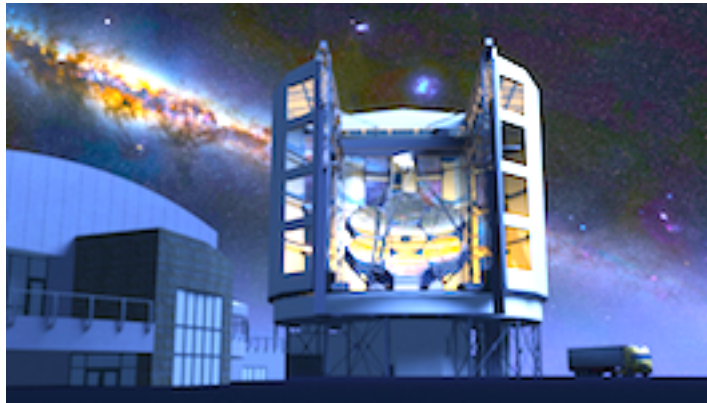
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and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- Astronomers are building a database of atmospheric fingerprints for 100ds of potential alien worlds.

### Detecting life from space

- In a 1990 flyby of Earth, Galileo took a spectrum of sunlight filtered through our planet's atmosphere.
- In 1993 Carl Sagan analyzed that data and found a large amount of oxygen together with methane — a telltale sign of life on Earth.
- These observations are a control experiment for the search of extraterrestres that gives us the key to explore alien worlds light years away.
- Current telescopes are not large enough to do so for smaller, Earth-like worlds.
- The James Webb telescope will let us study the atmospheres of these potentially habitable worlds.
- The Giant Magellan Telescope (GMT), planned for completion in 2020



- Europe's Extremely Large Telescope (E-ELT), ("first light" in 2024) — may also be able to contribute.
- With the expected discovery by TESS of thousands of nearby exoplanets, the James Webb and other large telescopes will have plenty of potential targets to study.
- ESA's **PLANetary Transits and Oscillations of stars (PLATO)**, (2022–24), will find even more candidates.
- Follow-up observation time will be costly and limited – hundreds of hours of observation.
- Astronomers will have to pick our targets carefully.

### Getting a head start

- Astronomers involved are putting together a database of atmospheric fingerprints of potential worlds.
- To start, they have modeled the chemical fingerprint of Earth over geological time.
- Earth's atmosphere has evolved over time, with different life forms producing and consuming various gases. These models may give astronomers some insight into a planet's evolutionary stage.
- Other models consider the effects of many factors on chemical signatures: water, clouds, atmospheric thickness, geological cycles, brightness of parent star, presence of different extreme extremophiles.
- It's a stepping-stone, saving time until we can get our first data to understand what we are seeing.
- We'll likely find things we never thought about in the first place.

### A new research center

- The spectral database is one of the main projects undertaken at the Institute for Pale Blue Dots – a new interdisciplinary research center founded in 2014 by Kaltenegger with inauguration on May 9, 2015.
- One goal is to better understand **what makes a planet a life-friendly habitat**, and how to detect other "pale blue dots" from light years away. ##

## Basic Ingredients for Life Found Around Distant Star

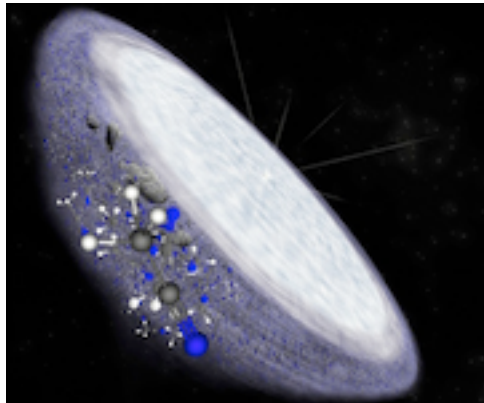
6 April, 2015 – [www.space.com/29049-life-ingredients-found-around-star.html](http://www.space.com/29049-life-ingredients-found-around-star.html)

Astronomers have just discovered complex organic molecules, the basic building blocks for life, in a disk of gas and dust surrounding another star.

- The organics, found around a young star, MWC 480, are thriving in quantities slightly higher than those thought to have existed in the early era of our own solar system.



- Our solar system is not the only one to contain these complex molecules, **suggesting that the ingredients required for life to evolve may exist throughout the universe.**
- The scientists created a video tour of the star MWC 48 to showcase their discovery.  
[www.space.com/29046-life-s-building-blocks-detected-around-young-star-video.html](http://www.space.com/29046-life-s-building-blocks-detected-around-young-star-video.html)
- The very rich organic chemistry found in this young solar system is not unique witness comets,
- The prebiotic chemistry that occurred in our solar system, happens elsewhere. Building blocks abound
- Located in the Taurus star-forming region 455 light-years away, MWC 480 is about twice the Sun's mass, and nearly 10 times brighter.
- A disk of material surrounds the million-year-old star
- But there are no obvious signs of planet formation.



Artist's impression of the protoplanetary disk surrounding the young star MWC 480, where the giant ALMA radio telescope has detected complex organic molecules – the building blocks of life – suggesting that conditions necessary for life are universal.

- MWC 480 was observed with the Atacama Large Millimeter/submillimeter Array (ALMA), in Chile.
- Enough methyl cyanide (a complex carbon-based molecule) in the disk surrounding the star to fill all of Earth's oceans.
- A supply of other complex carbon-based molecules was also found.  
[www.space.com/19098-alma-telescope-array-photos.html](http://www.space.com/19098-alma-telescope-array-photos.html)
- Volatile elements like cyanides boil away at high temperatures. Yet they are necessary for life.
- The simple volatiles in disks around other stars have remained more difficult to pin down.
- These complex elements exist in interstellar clouds between stars, but we were unsure if the elements could survive the energetic formation of a young solar system, where radiation could break bonds.
- But the material surrounding MWC 480 is awash in the building blocks of life.
- The team found cyanides throughout the disk, from 30–100 times the distance of Earth from the Sun.
- The region is comparable to our Kuiper Belt, where cold planetesimals and icy comets reside.
- The disk around MWC 480 contains more organic cyanides than the comets of Earth's solar system.
- This suggests that the building blocks for life may exist in planetary systems throughout the universe.
- We know from the Kepler mission and other searches that planets are incredibly common
- From these studies, we are learning that **the pivotal chemical compounds needed to seed early worlds with the volatiles required for life likely abound throughout the universe. ##**

## Life's Building Blocks Recreated in Space-Like Conditions

7 May, 2015 – [www.space.com/29338-life-building-blocks-meteorites-solar-wind.html](http://www.space.com/29338-life-building-blocks-meteorites-solar-wind.html)

Researchers have reproduced a wide array of building blocks for life in a prebiotic scenario that involves meteorites and the solar wind.

- They began with **formamide**, a simple organic compound that's ubiquitous. Formamide has been detected in galactic centers, star-forming regions and interstellar space, and comets and moons.

- They then added meteorite powder as a catalyst, and irradiated the solution with high-energy proton beams to simulate the solar wind.
- The result was a rich blend of complex biological molecules including amino acids, carboxylic acids, sugars and nucleobases (the basic building blocks for DNA and RNA).
- Among the products were also the nucleosides cytidine, uridine, adenosine, and thymidine, which are more advanced building blocks consisting of a nucleobase linked to a sugar molecule.
- Nucleosides are notoriously difficult to recreate under prebiotic conditions.
- Scientists were very surprised to see those.
- Ingredients for life have previously been recreated under a variety of possible terrestrial scenarios, some involving lightning, ultraviolet radiation, hydrothermal vents or meteorite impacts.
- The new findings expand the range of possibilities to prebiotic environments beyond the early Earth, including the small, wandering bodies on our solar system.

### Solar wind power

- The team had previously synthesized some building blocks (but no nucleosides) by subjecting formamide to very high temperatures, as in volcanic conditions or meteorite impacts on the early Earth.
- By instead irradiating formamide with high-energy protons, they obtained a higher yield of amino acids and nucleobases, as well as other relevant biomolecules including the nucleosides.
- Proton chemistry goes one step farther than heat chemistry.
- Carbon chemistry works the same anywhere in the universe, and every star produces solar wind.
- This tells us that life could well be universal.
- Interestingly, the scenario produced a high quantity of precursors for both metabolic and genetic pathways (the carboxylic acids and nucleobases respectively.)
- An ongoing debate in the origin of life is **whether metabolism or genetics emerged first**.
- The findings suggest that both processes could have emerged simultaneously.

### Meteorites as reactors

- Other findings suggest that meteorites may have seeded the ingredients for life on the early Earth, notably during the Late Heavy Bombardment, a period when the inner planets were pummeled by frequent impacts 4.1–3.8 billion years ago.
- Simple amino acids, sugars and nucleobases have been found inside meteorites, in small proportions.
- The researchers wanted to go beyond the idea of meteorites as mere carriers of organic molecules. They tested the catalytic properties of 11 meteorites belonging to the four major classes — iron, stony iron, chondrites and achondrites — first treating rock powder to remove any trace of organics.
- The minerals within the meteorites were necessary to catalyze the synthesis of the molecules, with the stony iron, chondrite and achondrite meteorites more active than the iron meteorites in general.
- They also tested individual minerals present in the meteorites and found that the full powder was needed for full catalytic effect.
- "Meteorites are not merely shuttles for organics, as suggests the common point of view. They are also reactors that can synthesize biomolecules during their lives."

### The catch

- The findings come with an important caveat.
- "I'm extremely enthusiastic about this piece of work because they obtained much more than the nucleobases," said Jan origin-of-life chemist at the Foundation for Applied Molecular Evolution, who wasn't involved in the new study. "They combined formamide and rock chemistry and got so many building blocks — that's what makes this paper important."
- "But the catch is that the total mass of meteorite that's coming in after the Moon-forming event is negligible. You can't rely on the Late Heavy Bombardment to bring you much in terms of organics. Besides, that amount of carbon is negligible compared to what's here on Earth already."
- Indeed, formamide, the starting molecule in their experiment, is readily made from hydrogen cyanide and water — two compounds that were abundant on the early Earth.
- We have to solve the problem with what's here on Earth before we go looking at meteorites, just because of the amount of material that's coming in ##

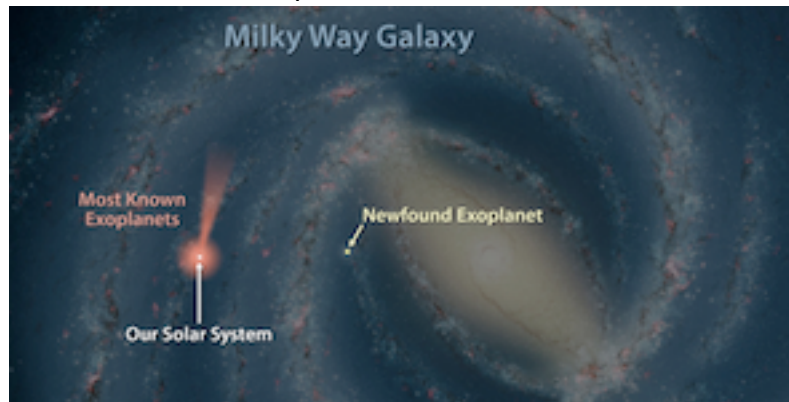
## Newfound Alien Planet Is One of the Farthest Ever Detected

16 April, 2015 – [www.space.com/29120-alien-planet-among-farthest-known.htm](http://www.space.com/29120-alien-planet-among-farthest-known.htm)

A NASA telescope has co-discovered one of the most distant planets ever identified: a gas giant about 13,000 light-years from Earth.

A NASA telescope has co-discovered one of the most distant planets ever identified: a gas giant about 13,000 light-years away from Earth.

- The technique used by the Spitzer Space Telescope, “microlensing”, is so new that it has only yielded about 30 planet discoveries so far. But the telescope's potential for finding far-away worlds is vast, NASA said in a statement. And as astronomers begin to chart the location of these distant bodies, it will provide a sense of where planets are distributed in Earth's Milky Way galaxy.
- We don't know if planets are more common in our galaxy's central bulge or the disk of the galaxy, which is why these observations are so important.



NASA's Spitzer Space Telescope co-discovered an exoplanet more than 13,000 light-years from Earth, far from where most known exoplanets are.

### Magnified starlight

- Microlensing happens when one star travels in front of another from the perspective of an observer (in this case, on Earth). When this happens, the gravity of the star in front magnifies the light of the star behind it, acting like a lens. Should the star in front have a planet, that planet would create a "blip" during the magnification, NASA said in the statement.
- The challenge is to pin down how far away the closer star (and its planet) is from Earth. Microlensing tends to magnify the star behind, but usually the star in front is invisible to observers. That's why about half of the 30 or so planets found with microlensing are at unknown distances from Earth.
- To overcome the distance problem, astronomers used the Spitzer telescope in concert with the Polish Optical Gravitational Lensing Experiment (OGLE) Warsaw Telescope at the Las Campanas Observatory in Chile. OGLE routinely does microlensing investigations.

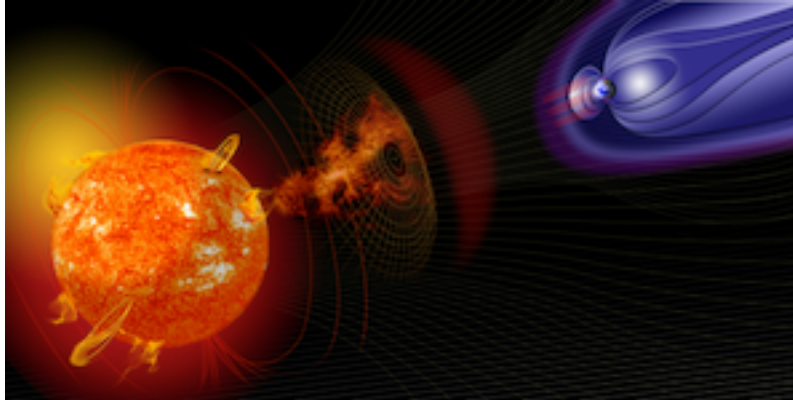
### Quick telescope work

- Prominent telescopes like Spitzer are usually fully booked with other astronomical observations. This makes it difficult to respond quickly when alerted about a microlensing event, lasting only 40 days on average.
- The new planet's microlensing event was quite long, roughly 150 days.
- As Spitzer orbits the sun from a position behind Earth 207 million km (128 million mi) away, the telescope sees microlensing events occur at a slightly different time than do telescopes on Earth.
- Spitzer spotted the "blip" in the magnification about 20 days before OGLE did. Comparing the delay between what Spitzer and OGLE saw, gives us the planet's distance from Earth, allowing us to estimate the planet's mass, roughly half that of Jupiter.
- So far, microlensing has helped astronomers find 30 planets at distances as far as 25,000 light-years from Earth = in addition to the one thousand plus closer worlds found by the Kepler space telescope.
- Astronomers are using the microlensing events to seek out planets in the central "bulge" of the Milky Way, a spot where stars are more densely packed and tend to cross more often. ##

## Wild Weather of Distant Stars May Affect Chances for Alien Life

20 May, 2015 – [www.space.com/29440-star-space-weather-alien-life.html](http://www.space.com/29440-star-space-weather-alien-life.html)

Earth regularly endures violent ejections of material from the Sun, but could similar eruptions in other solar systems make alien planets inhospitable to life? When material streams off of a star on a daily basis, it produces what scientists call "space weather." But the sun's weather may be mild compared to that of the most plentiful stars in the galaxy, M-dwarfs.



NASA artist illustration of how events happening on the sun can affect conditions around Earth.

Extrasolar planets — with and without magnetic fields — can also be affected when their stars are active.

- Two telescopes in the Mojave Desert are searching for these bursts of activity from stars, which could affect the development of distant planets and their potential for hosting life.
- Planets around M-dwarfs are going to be exposed to much more active space weather than Earth.
- Every day, charged particles carried from the sun by the solar wind bombard Earth. Sometimes, however, this space weather can become more extreme as the sun shoots bursts of plasma known as coronal mass ejections (CMEs) that have the potential to knock out our power grids and satellites.
- Without its magnetic field, Earth would experience even greater effects from these CME's: charged particles could strip Earth's ozone away for years, allowing harmful radiation to reach the surface.
- Because the sun is considered a typical star, it's likely that planets around other typical stars must also endure CMEs and space weather.
- Of particular interest are planets surrounding M-dwarf stars, which are smaller than the sun and far more long lived. Also known as red dwarfs, they make up approximately 70 % of the stars in the Milky Way, and some scientists suggest there may be as many as one planet for every red dwarf star.
- Though the long lives of M-dwarfs may provide enough time for life to evolve on planets in their systems, their extreme space weather may threaten those chances.
- Sudden flashes of brightness from the surface of a star, called flares, often precede CME's, and flares on red dwarfs are up to a thousand times more energetic than those on the sun.

**Editor:** [which is why recent papers suggesting life could arise around a red dwarf are poppycock.](#)

- For all their power, flares can be difficult to register. They appear at random, with no warning.
- Studies of CMEs on the sun are possible thanks to the array of telescopes dedicated to monitoring Earth's home star. Searching for them on nearby stars requires similar dedication.
- In order to better understand space weather outside of the solar system, on M-dwarfs as well as other types of stellar systems, Villadsen is studying 15 stars over two and a half years with two radio antennas at the Owens Valley Radio Observatory in California. Of the 15 targets, eight are red dwarfs.
- By keeping the stars in almost continual observation each evening, the scientists will be able to watch for the serendipitous explosions that will shed light on space weather around other stars.
- "To find these things, we really need to point at another star and wait," Villadsen said.
- Finding a zoo
- Although flares have been observed on other stars, no extrasolar CMEs have been identified. So the properties of extrasolar CMEs remain a mystery.
- "It's incredibly hard to detect with just about any method," Villadsen said.



- However, the sun demonstrates a relationship between strong solar flares and CMEs that other stars should replicate, she said. The selected targets are the closest flare stars within 7 light-years, which should mean these stars frequently spew CMEs.
- If the relationship between flares and CMEs scales for other stars — and Villadsen said she expects that it does — the targets should experience an extremely high rate of CMEs. Incidents such as the Carrington event, a powerful 1859 solar flare that resulted in a brilliant aurora and disrupted telegraph activity, could occur daily on these planets.
- To study CMEs ejected by the sun, spacecraft create a fake eclipse, blocking out the main body to allow scientists to see the outer atmosphere. Other stars aren't nearly as well resolved, making it impossible to see the diffuse outer layer in optical light from so far away. So, instead of searching in visible wavelengths, the scientists intend to study radio emissions from the stars, watching for activity that mimics CMEs on the sun in that spectrum.
- In addition to the observations made at Owens Valley, simultaneous observations will be made on occasion with other telescopes. These include the Very Large Array and the Very Long Baseline Array, whose greater sensitivities will provide a better understanding of the activity on these distant stars. Other observations will be triggered when the Starburst project detects large flares.
- The observations should reveal multiple events on the active stars, which would allow the team to identify and characterize CMEs ##

## In Search for Alien Life, Experts Reveal Cutting-Edge Science

17 June, 2015 - [www.space.com/29684-search-for-alien-life-science-technology.html](http://www.space.com/29684-search-for-alien-life-science-technology.html)

CHICAGO - Where can scientists find clues to help them locate and understand life beyond Earth? According to speakers at the 2015 Astrobiology Science Conference, **the hunt begins in many locations, from planets beyond our solar system to the ground beneath our feet.**

- At a NASA news briefing, three speakers discussed a wide range of ways that scientists are assisting in the search for life elsewhere in the universe.
- Those efforts include studies of
  - ✓ **extreme life-forms on Earth,**
  - ✓ **photographs of the sun glinting off Earth's ocean, and**
  - ✓ **studies in Antarctica that will assist a mission to one of Jupiter's icy moons.**

**Rock-powered life—"Organisms might not need direct exposure to sunlight, but could live in subsurface environments.**

- "[We're] quite interested in the capability of rocks to store energy within them to be used to power biological systems
- There's a fundamental understanding that, depending on their chemistry, rocks have within them the **ability to release electrons or components that can fuel and power different systems essentially much like fuel cells do.**
- A big question is how can we couple the energy that's stored within rocks into biological systems."
- If rocks can serve as an energy source for life, it opens new possibilities for where life could thrive.
- A group is investigating life-forms found **in the deserts of Oman**, where rocks formed in the Earth's mantle have come to the surface.
- Prolonged contact between the rocks and water pools of water changes water, making it very alkaline.
- Life-forms found in these pools are not only surviving, but are optimized to thrive.

**Icy worlds and relevant missions to "icy moons" and Antarctica**

- This may be relevant to the search for life in sub-surface oceans such as on Europa and Enceladus.
- NASA recently announced a suite of instruments that the agency selected for a planned Europa mission
- A vehicle called "Icefin," is currently exploring the ocean below the Antarctic ice.
- Another instrument, Artemis, will perform long-range exploration under the ice
- Another project will conduct ice-penetrating radar studies of the ice shelves of the Antarctic

**A glimmer of life; Signs of life through direct observations of exoplanets:**

- An image taken by the LCROSS satellite of the Earth as a partially illuminated crescent. The curved sliver of light was not uniform — it featured a slightly brighter section right near its midpoint. That, was a glint of sunlight reflecting off the ocean.
- **Such a glint even effect might reveal the presence of an ocean on a distant exoplanet.**
- Work has also been done \to help narrow down **what kind of elements and molecules in a planet's atmosphere might indicate the presence of life.**
- "We now are getting a much more mature view of what we should be looking for and what might fool us. We know in particular which targets we should choose preferentially that will help us avoid these false positives for life and also what other things in the planetary spectrum we should look for that might help us figure out what's going on." ##

## Why Aren't Aliens Calling Earth?

18 June, 2015 – [www.space.com/29683-why-arent-aliens-calling-earth.html](http://www.space.com/29683-why-arent-aliens-calling-earth.html)

We've been conditioned by television and movies to accept the likelihood of intelligent life elsewhere in the universe. The first person to address this question in a systematic way was Frank Drake, who invented **the Drake Equation** to predict the number of extraterrestrial civilizations in the galaxy. His equation is rather complicated, but here's a simple version of his argument.

### How many suitable planets?

- First, let's count how many stars are in the galaxy. "Billions upon billions" And how many of those stars have planets? Until recently, we really didn't know.
- Over the past 20 years, astronomers have made remarkable progress in discovering planets around other stars. We now know that many stars have planets orbiting them.
- But is it likely that we're not alone in the universe? And if intelligent life is out there, why haven't they contacted us yet?
- Could creatures actually live on any of those planets? Many of them are just giant balls of gas, or else too hot or too cold to contain liquid water, which is the basis of all life on Earth.
- But a few of them do seem to be at the right temperature. These are "the Goldilocks planets: not too hot and not too cold for liquid water."
- How likely is it that life will develop on a potentially habitable planet? We don't know the answer, but **life on Earth got going very shortly after the formation of our solar system, and it has wedged itself into every available niche, no matter how hostile.**
- Colonies of bizarre creatures flourish in perpetual darkness **near deep ocean vents, where super-heated sulfur-rich water spews from under the ground.**
- **Radiation-resistant bacteria** bask happily in levels of radioactivity that would instantly kill a human.
- And then there's the tardigrade, which looks like a microscopic eight-legged teddy bear, that can thrive in liquid nitrogen or boiling alcohol.
- So the probability of life developing on habitable worlds seems very high.

### But how likely is it that this life will develop intelligence?

- "We haven't got a clue"). But many scientists consider intelligent life almost inevitable, in which case the galaxy should be teeming with alien civilizations.

### If the galaxy is crawling with aliens, where are they? The Fermi Paradox

- Interstellar travel is limited by the speed of light: it's no surprise that no one has visited us.
- But should we at least be able to detect alien radio signals. Why haven't our alien friends contacted us? Everything suggests alien civilizations should be ("relatively") common, yet we've seen no sign of them.
- One possibility is that intelligent life really is rare. While life developed in the relative blink of an eye after the birth of the solar system, it took billions of years before we smarties showed up on the scene. And remember that "survival of the fittest" doesn't always mean "survival of the smartest."
- While intelligence is certainly a useful survival trait, it seems far from inevitable. If not for an errant asteroid, the dinosaurs might still rule the world.

**(Editor: there are many signs that our civilization is somewhat suicidal. Is that typical?)**

- Another possibility is that intelligent life inevitably destroys itself. Until recently, our options for total self-destruction were limited to nuclear weapons. But we are on the edge of expanding our armada to include genetically engineered viruses (think: Ebola meets the common cold!).

### Runaway nanobots

- And consider the dangers posed by nanomachines, tiny self-replicating robots programmed to convert matter into more robots. Imagine a tiny robot, no bigger than the width of a human hair, designed to provide some useful function, programmed to build a copy of itself, using materials from its environment. Now you have two machines, and both can create duplicates, giving us four machines. But what if this process got out of control? The nanomachines could rapidly consume the entire Earth, converting it, along with everyone on the planet, into "grey goo".

### Do intelligent sytesms learn to hide?

- Maybe the galaxy is a dangerous place, full of robotic probes sent out by hostile aliens to wipe out any competition, so everyone else is in hiding.
- An even more bizarre suggestion is that superior civilizations have decided to avoid contact with lesser beings such as ourselves, so that we live in a kind of cosmic zoo, complete with a "Do not talk to the animals" sign.

**(Editor: or more simply, intelligent civilizations remain hidden to let juvenile civilizations find their own way to adulthood - such as in Star Trek's famed "Prime Directive."**

**But there is another filter, that of Physics. It is very cheap to :“listen” but prohibitively expensive to put out signals that remain strong enough and noise free enough to reach in all directions over astronomical distances. Given these barriers,**

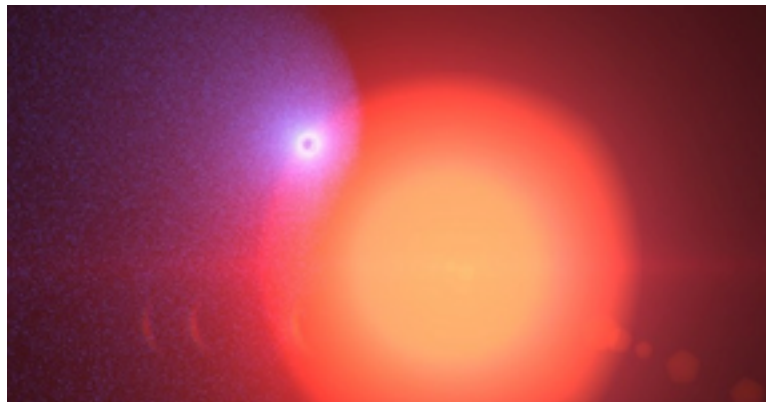
**Only an insanely evangelistic civilization could or would keep broadcasting in all directions continuously forever. With the signals getting weaker and weaker and subject to becoming noisier with distance, communicating is an insane idea.**

**If we do hear a signal, best to keep silent. Beware of “ISIS” civilizations! PK**

## Bizarre Cometlike Alien Planet Is First of Its Kind

24 June, 2015 - [www.space.com/29752-cometlike-planet-first-of-its-kind.html](http://www.space.com/29752-cometlike-planet-first-of-its-kind.html)

A Neptune-size planet appears to be masquerading as a comet, with a gargantuan stream of gas flowing behind it like a comet's tail.



Artist's impression showing the warm, Neptune-size exoplanet GJ 436b at the beginning of its transit across the surface of its parent star, a red dwarf that is half the diameter of the sun. The planet is 33x closer to its parent star than the Earth is to the sun, heating the atmosphere to the point where it expands and escapes the planet attraction. The star is, however, 40x fainter than the sun, allowing the evaporating atmosphere to form a giant cloud surrounding and trailing the planet, much like a comet.

- The bizarre find is the first of its kind ever discovered by astronomers. **GJ 436b**, a strange, cometlike planet about 22 times as massive as Earth, is orbiting a red dwarf star. Astronomers detected the giant gas cloud around the planet using NASA's Hubble Space Telescope and Chandra X-ray Observatory.
- The mere size of the cloud of gas escaping from the planet was astonishing.
- About 33 light-years from Earth in the constellation Leo, it is a kind of world known as a warm Neptune. Such planets, at about 10 to 20 times the mass of Earth, are about the mass of Uranus and Neptune — but they are as close, or closer, to their stars than Mercury is to the Sun. With an orbit of only about 4.8 million km (3 million mi), 33 times closer to its star than Earth is to the sun, and 13 times closer than Mercury."
- The cloud of gas around GJ 436b, made up mostly of hydrogen, has a circular head that surrounds the planet, with a tail trailing behind. The diameter of the head is about five times the width of the host star, which is about half that of the Sun. The length of the tail is uncertain as observations do not cover it entirely, but their computer models suggest it could be about 15 million km (9.3 million mi) long.
- Although prior research has predicted that other gas giants should be blowing off cometlike tails, based on how hot they must be due to their proximity to their stars, "GJ 436b is the first planet for which a cometlike tail is confidently detected," Ehrenreich said. (A previous study revealed indirect evidence of "a rocky world that appears to be disintegrating around its host star, creating a cometlike tail of material behind the planet. That study used data from NASA's Kepler space telescope, which observed scattering of the light from the planet's host star.)
- Scientists estimated that GJ 436b is currently blowing off up to 1,000 tons of gas per second.
- GJ 436b is currently losing about 0.1 % of its atmosphere every billion years, which is far too slow a rate to deplete its atmosphere in the lifetime of its parent red dwarf star.
- However, when the star was more active in its infancy, the researchers estimated that c
- Recently, it was suggested that GJ 436b might possess a helium-rich sky depleted of hydrogen.
- But in order to be really hydrogen-poor and helium-rich, the atmosphere of GJ 436b should have represented a very small fraction of the planet's initial mass, around one-thousandth," Ehrenreich said. "In such a case, the whole atmosphere would have been gone today, which as we measure is not the case."
- The Kepler space telescope, as well as NASA's upcoming TESS space mission and the European Space Agency's future CHEOPS and PLATO spacecraft could find thousands of similar systems,
- Scientists now plan to investigate less massive planets, such as "super-Earths" and "mini-Neptunes" to see if they might also have puffy atmospheres and cometlike tails. ##

## Visible Light Spectrum from Alien Planet Measured for 1st Time (Video)

22 April, 2015 – [www.space.com/29174-exoplanet-first-visible-light-spectrum-video.html](http://www.space.com/29174-exoplanet-first-visible-light-spectrum-video.html)

Astronomers have detected an exoplanet's visible-light spectrum directly for the first time ever, a milestone that could help bring many other alien worlds into clearer focus down the road.

- Scientists used the HARPS instrument on the European Southern Observatory's 3.6-meter telescope at the La Silla Observatory in Chile to study the spectrum of visible light reflected off the exoplanet **51 Pegasi b**, about 50 light-years from Earth in the constellation Pegasus, spotted in 1995.
- **HARPS** is short for **H**igh **A**ccuracy **R**adial velocity **P**lanet **S**earcher)
- 51 Pegasi b is a "hot Jupiter" gas giant that orbits close to its parent star, and became the first alien world ever discovered around a sunlike star.
- (The first exoplanets of any type were found in 1992 around a superdense, rotating stellar corpse called a pulsar.)
- Researchers most often study exoplanet atmospheres by analyzing the starlight that passes through them when worlds cross their stars' faces from Earth's perspective.
- This method, known as transit spectroscopy, is restricted to use on systems in which the stars and planets align in our line of sight..
- The new strategy used with 51 Pegasi b, on the other hand, does not depend on planetary transits and could thus find broader applicability.
- The technique offers other scientific advantages as well. It allows us to measure the planet's real mass and orbital inclination, which is essential to more fully understand its solar system..



- It also allows us to estimate the planet's reflectivity, or albedo, which can be used to infer the composition of both the planet's surface and atmosphere.
- The new data suggest that 51 Pegasi b is highly reflective, a bit larger in diameter than Jupiter and about half as massive.
- The new observations by HARPS provide a vital proof of concept for the new technique, which could really come into its own when employed with instruments on bigger telescopes, such as the European Southern Observatory's Very Large Telescope (VLT).
- We are now eagerly awaiting first light of the ESPRESSO spectrograph on the VLT so that we can do more detailed studies of this and other planetary systems. ##

## Nearby Alien Planets Not So Life-Friendly After All

24 April, 2015 – [www.space.com/29191-exoplanets-tau-ceti-alien-life.html](http://www.space.com/29191-exoplanets-tau-ceti-alien-life.html)

The odds of finding alien life in our solar [system's](#) backyard have just taken a bit of a hit.

- The star Tau Ceti, which lies just 11.9 light-years from Earth, is thought to host five planets, two of which have been posited to lie in the "habitable zone" — that just-right range of distances that could support the existence of liquid water on the planets' surfaces.

**Editor:** [Tau Ceti, the closest "single" sun-like star< has been a favorite of science fiction writers over the years. So ends a tradition!](#)

- However, a new modeling study throws some cold water on the life-supporting potential of these two candidate worlds, **Tau Ceti e** and **Tau Ceti f**.
- **Planet e** is in the habitable zone only if we make "very generous assumptions"
- **Planet f** modeling the evolution of the star makes it seem probable that it has only moved into the habitable zone recently, as Tau Ceti has gotten more luminous over the course of its life.
- **Tau Ceti f** has likely resided in the habitable zone for much less than 1 billion years, so even if the planet currently supports life as we know it, astronomers may have a hard time finding any signs of life in the world's atmosphere. After all, it probably took about 2 billion years for detectable "biosignatures" to build up in Earth's air after the first organisms evolved.
- The other three Tau Ceti planets (b, c and d) all orbit considerably closer to the star than do e and f, making them likely too hot to harbor life.
- All five Tau Ceti worlds are likely larger than Earth. Planets e and f may be 4.3 and 6.6 times more massive than Earth, respectively; the other three appear to harbor between 2 and 4 Earth masses.
- Tau Ceti has much more magnesium compared to silicon than the Sun does. As a result, the Tau Ceti worlds could be quite different from Earth in key ways that are not just related to size.
- The mineralogical makeup of Tau Ceti's planets could be significantly different from Earth's, possibly dominated by the mineral olivine in the upper mantle and by ferropericlase in the lower mantle.
- Since ferropericlase is not very viscous, the rock within the mantles of Tau Ceti worlds may flow more easily than mantle rock does on Earth, with potentially large impacts on volcanism and plate tectonics.
- While life around Tau Ceti may be unlikely, it should should invigorate our curiosity.
- The Tau Ceti candidate planets aren't the closest extrasolar worlds to Earth. In 2012, we found the existence of an Earth-size, scorching-hot planet around Alpha Centauri just 4.3 light-years away. ##

## NASA Launches Project to Help Search for Alien Life

27 April, 2015 – [www.space.com/29205-nasa-alien-life-search-exoplanets-nexss.html](http://www.space.com/29205-nasa-alien-life-search-exoplanets-nexss.html)

A new NASA initiative will help lead the search for signs of life beyond our solar system.

- The Nexus for Exoplanet System Science, or NExSS, will take a multidisciplinary approach to the hunt for alien life, bringing together experts in **Earth science, planetary science, heliophysics** and **astrophysics** to get a better understanding of **how life might emerge and develop around distant stars**.
- This interdisciplinary endeavor connects top research teams and provides a synthesized approach in the search for planets with the greatest potential for signs of life.
- The hunt for exoplanets is a priority for astronomers, and planetary and climate scientists as well.##

## How Studying Saturn's moon Titan could unlock Secrets of Alien Planets

27 April, 2015 – [www.space.com/29209-saturn-moon-titan-atmosphere-exoplanets.html](http://www.space.com/29209-saturn-moon-titan-atmosphere-exoplanets.html)

With nearly 2,000 confirmed planets beyond our solar system, astronomers are attempting to **identify the atmospheres** of these distant bodies to determine if they could possibly host life.

- Astronomers are honing their techniques in exoplanet observation using an object we know much more about in our own solar system — Saturn's largest moon, Titan.
- The purpose is to better understand what a signal from a hazy planet similar to Titan would look like.
- In reading signals from the atmospheres of other planets, it is difficult to sort out the differences between a thick cloud of smog-like haze from pockets of gas.
- Observers must contend with noise, extraneous signals not related to the planet they are studying.
- Does the signal come from material the light encounters along the way from the planet to Earth or from mechanical issues with the instruments?
- Noise static may blur actual readings, making it hard to sort haze signals from gas signals from noise.
- Titan provides an almost noise-free dataset to help exoplanet observers interpret their observations.

### A haze-dominated 'planet'

- As a distant planet passes in front of its star, light passes through the atmosphere. By studying that passage with a variety of wavelengths using a method known as transit spectroscopy, scientists can see how the signal changes with each observation and determine the composition of the atmosphere.
- Some exoplanets have returned featureless readings, no signs indicating atmospheric composition.
- To scientists, this suggests a high layer of clouds, or haze, in the atmosphere that absorbs the light from the star, blocking readings of the lower atmosphere that can tell scientists more about the planet's atmosphere and its potential habitability.
- High-altitude cloud layers in the atmospheres of exoplanets are usually quite obvious.
- But these cloud layers are hiding the atmospheric absorption signals scientists want to measure.
- High-altitude clouds can make a small planet with a puffy, hydrogen-rich atmosphere look like it has a much more compact atmosphere made of heavier gases, such as water or carbon dioxide."
- To understand how high-altitude hazes can affect the passage of light through the atmosphere
- Using Cassini, they observed the sun rising and setting through Titan's atmosphere, an occultation.
- For this, Cassini is located fairly close to Titan, while the sun is relatively far away.
- For exoplanet studies, the situation is reversed.
- The host star is relatively close to the planet, while observers on Earth are far away from the system.
- Occultations in the Solar System and in the transits of exoplanets are perfectly complementary,
- In both cases, the light that is transmitted through the atmosphere carries with it spectral signatures of whatever gases, hazes, and clouds might be present in the planet's atmosphere.
- Titan is a perfect test for understanding hazy worlds, as the haziest body in the solar system, with a nitrogen-rich upper atmosphere and clouds that send methane rain falling onto its surface. ##

## Rocky Planets May Have Formed from Tiny Particle Clusters

30 April, 2017 – [www.space.com/29280-rocky-planets-asteroids-growth-explained.html](http://www.space.com/29280-rocky-planets-asteroids-growth-explained.html)

A new study suggests that clumps of small, glassy particles may be responsible for the formation of giant asteroids and the planetary "embryos" that collided to form rocky planets like Earth.

- Asteroid fragments that fall to Earth as meteorites often contain tiny, round pellets known as **chondrules** that formed when molten droplets quickly cooled in outer space during the solar system's early years. Chondrules are found in 92 percent of all meteorites.
- Previous work suggested that chondrules were the building blocks of asteroids, which, in turn, often have been thought to be the building blocks of planets.
- Now, computer simulations modeling the behavior of more than 150 million particles in space reveal how chondrules might have coalesced into asteroids.

- After the Sun was born, the rest of the solar system emerged from a giant rotating [cloud](#) of gas and dust known as the "protoplanetary disk.
- Researchers found that, as chondrules moved through gas in this disk, the friction between the particles and the gas slowed down the chondrules, allowing them to cluster.
- The researchers calculated that the largest of these clusters of particles could gather enough chondrules within about 3 million years to grow into planetary embryos, the moon-to planet-sized chunks of rock that careened around the solar system before planetary formation finished in the solar system.
- The asteroids did not stop growing when they reached the size of [Ceres](#), the largest asteroid in the current asteroid belt. Rather, the largest bodies grew to [be] the same size as Mars.
- These planetary embryos might have collided in giant impacts over 30 million to 100 million years to form the rocky planets and moons present in the solar system today.
- The implication is that chondrules may not only have been responsible for the growth of asteroids, but also for the formation of terrestrial planets,
- Mars may be a remnant that avoided being incorporated into a larger planet like Earth or Venus."
- Another recent study had suggested that chondrules are the byproducts of cosmic impacts between planetary embryos.
- However, these new findings suggest that chondrules are actually the building blocks of planetary embryos. "Without chondrules, no large asteroids or planetary embryos will form. ##

## In Search for Alien Life, Follow the Water

30 April, 2015 – [www.space.com/29272-water-solar-system-search-for-life.html](http://www.space.com/29272-water-solar-system-search-for-life.html)

The search for life beyond Earth [homes](#) in on water, whose abundance throughout the solar system is becoming increasingly clear to scientists. **Water is key to life as we know it,**

- **Water is a polar molecule and a solvent, two properties that are important for chemical reactions critical to life.**
- Earth is certainly not the only world with ample stores of water. Jupiter's moon **Europa** is covered with a sheet of ice that very likely sits on top of a [global](#) ocean, and Saturn's moon **Enceladus** shows evidence of subsurface water as well.
- **Mars was once a relatively warm and wet world** that apparently endowed with large amounts of water in the ancient past for a long period of time — perhaps up to a billion years,.
- Astrobiologists regard Europa and Enceladys as viable candidates to host alien life today.
- While researchers might not find life on Mars now, it might have existed there once.
- Many in the scientific community have a pretty [strong](#) belief, based on science, that at some point life was likely to have evolved on the surface of Mars. The hard part is going to be finding it.
- Any [Martian life](#) that is found today is likely to be microbe.

### Here on Earth

- Satellite-based studies of water use help farmers understand how to use water more efficiently.
- Only 2.4 % of all the water on Earth is fresh water, and humans can use only a fraction of that, about 0.4% of the total. Of that, about 70–90 % is used for agriculture.
- Plans to settle humans on Mars can be connected with how we use water on Earth, and technologies for recycling might have Earthbound applications.
- On the Space Station some 85% of the water is recycled.
- To get to Mars, that percentage will have to be even higher.
- There isn't any liquid water on Mars' surface, and getting at the stuff might not be easy.
- Mars is not a 'live off the land' kind of place.
- **The likely route will be to pre-position some kind of water extraction apparatus on [Mars](#) before sending humans.**

### On other worlds, water is even harder to access.

- On the Moon, much of it is locked in clathrates, compounds in which water molecules are trapped inside molecular lattices. Getting the water out is not easy. ##

## New 'Super Earth' Exoplanets Spotted Around Nearby Star

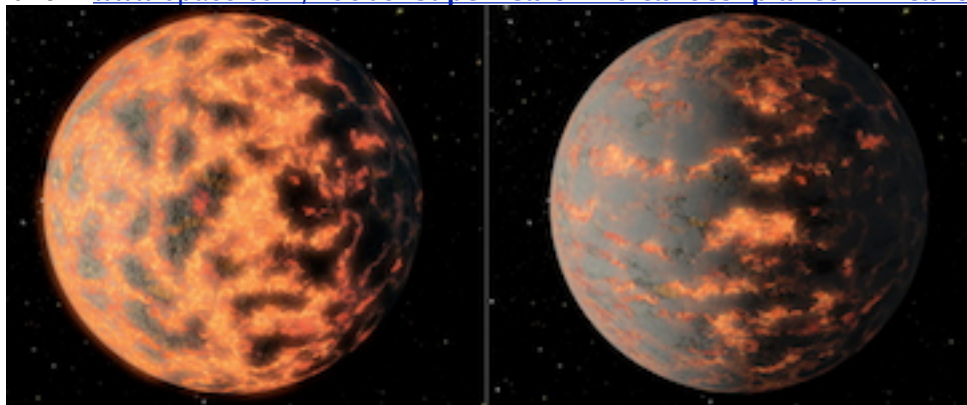
1 May, 2015 – [www.space.com/29286-nearby-super-earth-alien-planets.html](http://www.space.com/29286-nearby-super-earth-alien-planets.html)

Astronomers have discovered two new alien worlds a bit larger than Earth circling a nearby star.

- The newfound exoplanets, known as HD 7924c and HD 7924d, are "super Earths" with masses about 7.9 and 6.4 times greater, respectively, than that of our home planet.
- Both planets orbit the star HD 7924, just 54 light-years from the Sun — a mere stone's throw considering the size of the Milky Way, which is on the order of 100,000 light-years wide.
- Another super Earth, called HD 7924b, was spotted there in 2009.) HD 7924b, HD 7924c and HD 7924d all lie closer to their host star than Mercury does to the sun. They complete one orbit in five, 15 and 24 days, respectively.
- These three planets are unlike anything in our solar system, with masses 7–8 times that of Earth and orbits that take them very close to their host star.
- The research team discovered HD 7924c and HD 7924d using three different ground-based facilities — the Automated Planet Finder (APF) Telescope at Lick Observatory in California, the Keck Observatory in Hawaii and the Automatic Photometric Telescope (APT) at Fairborn Observatory in Arizona. (Keck also found HD 7924b in 2009.)
- The research team used the combined observations of the three telescopes to detect tiny wobbles in the star HD 7924 caused by the gravitational pull of the two newfound planets.
- Starspots (sunspots) on the sun can momentarily mimic the signatures of small planets. Repeated observations over many years allowed us to separate starspot signals from new planet signatures.
- The APF Telescope was recently revamped to make it fully robotic, and now searches the skies for exoplanets without human oversight — a key milestone in the ongoing exoplanet hunt.
- This level of automation is a game-changer in astronomy – like owning a driverless [car](#) that goes planet shopping."
- Astronomers first found planets orbiting another star in 1992, and the exoplanet tally has now risen to nearly 2,000. More than half of these alien worlds have been discovered by [NASA's Kepler space telescope](#), which launched in March 2009.

## Alien Volcanoes on 'Super Earth' May Explain Wild Temperature Swings

5 May, 2015 – [www.space.com/29303-super-earth-volcanoes-planet-55-cancri-e.html](http://www.space.com/29303-super-earth-volcanoes-planet-55-cancri-e.html)



Artist's concept of the exoplanet 55 Cancri e, which may host large and active volcanoes

Temperatures on a nearby "super Earth" exoplanet varied dramatically recently, suggesting that large and very active volcanoes may exist on the alien world's surface.

- Researchers using NASA's Spitzer Space Telescope found that temperatures on 55 Cancri e — a planet eight times more massive than Earth and that lies 40 light-years away — swung between about 1,832 to 4,892 °F (1,000 to 2,700 °C).
- No thermal emission signature or surface activity has yet been detected for any other super Earth
- This atmospheric variability was observed on the "day side" of 55 Cancri e, which lies so close to its host star that it completes one orbit every 18 hours.



- The planet is tidally locked – one side always faces the star and the other always faces away.
- A likely explanation for this variability is [that] large-scale surface activity, possibly volcanism, on the surface is spewing out massive volumes of gas and dust, which sometimes blanket the thermal emission from the planet, so it is not seen from Earth.
- If this interpretation is correct, volcanism on 55 Cancri e would likely be even more intense than it is on Jupiter's moon Io, the most volcanically active body in our solar system.
- WE once thought that 55 Cancri e was so carbon-rich that it was composed largely of diamond, but recent studies suggest that the planet's carbon abundance may have been overestimated. This further adds to the mystery and intrigue of 55 Cancri e, one of five planets known to orbit the star 55 Cancri.
- The planet could still be carbon-rich, but now we're not so sure. Earlier studies of this planet have even suggested that it could be a water world.
- The present variability [in temperature] is something we've never seen anywhere else, so there's no robust conventional explanation.
- But that's the fun in science — clues can come from unexpected quarters. The present observations open a new chapter in our ability to study the conditions on rocky exoplanets using current and upcoming large telescopes. ##

## Polluted Star Hints at Water's Origins on Earth and Alien Planets

7 May, 2015 – [www.space.com/29336-polluted-white-dwarf-asteroids-water-earth.html](http://www.space.com/29336-polluted-white-dwarf-asteroids-water-earth.html)

Astronomers have spotted a dead star polluted with heavy elements, suggesting that the star recently chowed down on a water-laced asteroid.

- The destructive process hints at how asteroids probably delivered water to Earth billions of years ago. But it also hints at how asteroids likely deliver water to exoplanets in other planetary systems.
- Research has found that, rather than being unique, water-rich asteroids similar to those found in our solar system appear to be frequent.
- Thus, many planets may have contained a volume of water, comparable to that contained in the Earth.
- Astronomers once thought that white dwarfs — the Earth-size remnants of low-mass stars like our sun — were pristine. Their intense gravity should pull the heaviest elements down into their depths relatively quickly (thousands of years at most).
- In white dwarfs hundreds of millions of years old, we do not expect any heavy element to stay in their atmospheres for long,
- When the team observed the white dwarf in question (SDSS J1242+5226), they saw that it was smothered in oxygen, magnesium, silicon, iron and other heavy elements. Even hydrogen was far more abundant than expected. These elements match what water expect to see in a water-rich asteroid.
- It's likely that the asteroid passed close to the white dwarf, whose intense gravity shredded it into smaller particles. These particles then formed a disk around the dead star, and slowly rained down over time — polluting the star's surface with its elements. Because those elements are still expected to sink to the center of the star, the destructive event probably happened fairly recently, Raddi said.
- Astronomers suspect that the asteroid was initially comparable in size to Ceres, the largest known asteroid in the solar system,. And it likely contained enough water to fill 30% of the Earth's oceans.
- The result sheds ight on how asteroids can deliver water to stars and other orbiting bodies.
- Geologists don't think Earth's water has been here for too long. The Moon-forming impact would have melted the Earth's crust and mantle, vaporizing any water. Instead, asteroids likely delivered water to Earth in the young solar system.
- And this research shows that this process was not unique to our solar system. It's likely occurring throughout planetary systems in the galaxy.
- "Our work reinforces previous evidence that water-rich asteroids are common in other planetary systems. It also confirms that asteroids can deliver their constituents (rocks and ice) onto the surface of planets in the inner parts of the planetary systems orbiting other stars, likely within what is known as the habitable zone."
- The team made their observations on the U.K.-owned William Herschel Telescope in the Canary Islands, Spain.##

## 'Venus Zone' Narrows Search for Habitable Exoplanets

7 May, 2015 - [www.space.com/29337-habitable-alien-planets-venus-zone.html](http://www.space.com/29337-habitable-alien-planets-venus-zone.html)

[www.spacedaily.com/reports/Venus\\_Zone\\_Narrows\\_Search\\_for\\_Habitable\\_Planets\\_999.html](http://www.spacedaily.com/reports/Venus_Zone_Narrows_Search_for_Habitable_Planets_999.html)

[Text "abridged" rather than "bulletized"]

Long before the hunt began to find Earth lookalikes around other stars, one planet in the solar system had already been named Earth's twin. With its similar size and mass, **Venus** measures very close to Earth, with one major yet significant difference: Its thick atmosphere makes temperatures on the planet hot enough to melt lead, and therefore most certainly too hot to sustain life.

- To weed out Venus-like planets from those that would be more habitable, several scientists proposed the establishment of a "Venus zone" around stars, a region where the atmosphere could be consumed by a runaway greenhouse effect that superheats its planets.



Size is no indicator of habitability. In other words, just because a planet is roughly the size of Earth, instead of, say, Jupiter, doesn't guarantee that the conditions are right for life to evolve.

### Defining the 'Venus zone'

- The region around a star where liquid water can exist on a planet's surface is the "**habitable zone.**"
- Just because liquid water can exist doesn't mean that it does. Finding out the conditions on a planet often requires follow-up observations to initial discoveries.
- Limitations on observation time and equipment mean prioritizing which planets should be the first to be studied in-depth.

**"The primary purpose of the habitable zone is target selection."**

- NASA's Kepler Telescope's Habitable Zone working group seeks to utilize all available data and to provide the most robust list of habitable-zone planets discovered by the telescope.
- The goal is to better understand how common Earth-size planets are in stars' habitable zones.
- The "Venus zone" would similarly serve as a target-selection area.

**The establishment of a Venus zone would narrow down the inner edge of potential habitability.**

- A planet within the Venus zone may form an ocean at some point in its history.
- Venus is thought to have harbored water on its surface until approximately one billion years ago.

**"Venus Zone" inner edge:** (The point at which a planet would lose its oceans due to its sun's energy.

- Losing liquid water would inhibit the carbon cycle of a planet, allowing more to build up in the atmosphere. Rising carbon levels would kick off a runaway greenhouse effect that would heat the planet.
- Losing liquid water inhibits the carbon cycle of a planet, allowing more to build up in the atmosphere. Rising carbon levels would kick off a runaway greenhouse effect that would heat the planet.

**The outer edge of the "Venus Zone" = the inner boundary of the "habitable zone"**

- The runaway greenhouse effect for a planet can be avoided if it experiences significant atmospheric loss preventing the carbon from building up and superheating the planet. "

### Finding exo-Venus planets

- Studying planetary atmospheres requires advanced telescopes and the right kind of stars - and significant telescope time - which can be a showstopper.

**The Transiting Exoplanet Survey Satellite, or TESS,**

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- TESS will map exoplanets around the brightest stars in the sky after its **2017** launch.
- Because TESS searches for planets that are observed as they cross their star's face from the telescope's perspective — it will be more sensitive to those that orbit closer to their sun.
- "TESS will see a lot more "exo-Venuses" than it will :exo-Earths.
- This is important as these are the planets to rule out in the search of for real exo-Earths.
- Studying more exo-Venuses will help to **narrow down the line between the Venus zone and the habitable zone**, helping scientists to pinpoint which Earth-size planets are Earth twins, and which bear a stronger resemblance to Venus.
- We will then be able to determine more accurately the boundary between them. Currently, that boundary is based entirely on theoretical climate models, which may not be very accurate. ##

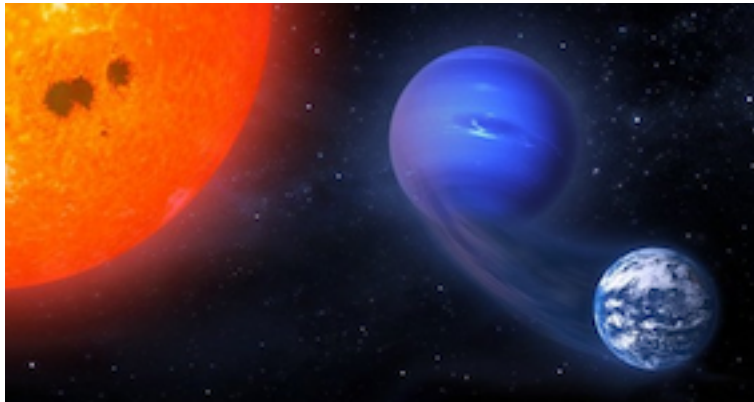
## Life Needs An Atmosphere, But How Much Is Too Much?

7 May, 2015 - [www.space.com/29342-dwarf-stars-could-make-atmospheres-hospitable.html](http://www.space.com/29342-dwarf-stars-could-make-atmospheres-hospitable.html)

### Super-Earths vs. mini-Neptunes - How much atmosphere is too much for life?

- As scientists discover more Super-Earths vs. mini-Neptunes, the question becomes more relevant.

Often, the rocky cores of these planets are believed to be about the same size, while the distinguishing difference is the size of the atmosphere. "Mini-Neptunes" look more like gas giants, with a thicker atmosphere that creates too much surface pressure. "Super-Earths" have a much thinner layer.



New research indicates that M dwarf stars could strip away just enough atmosphere from mini-Neptunes to make them more habitable.

- A recent research study considered what would happen if a mini-Neptune migrated close to a dwarf M-class star which have a volatile first billion years. Energy production from the star can range drastically, with X-rays and extreme ultraviolet rays hitting planets with as much as 100 to 10,000 times more radiation than what Earth experiences today.
- For habitability, this is a huge challenge. Because the star is smaller, rocky planets need to huddle in closer to be within the star's "habability zone." But there, the radiation emanating from the star in its youth slams into the atmosphere, stripping away molecules until there is little left.

### What if a mini-Neptune got in close because the gravity of its star?

- There appears to be a small set of situations where the planet could hold on to just enough atmosphere to become a "super-Earth" - a planet that is a little larger than Earth but still small enough to have a reasonable-sized atmosphere.
- This is a situation that could lead to the formation and evolution of life "as we know it."
- In such a scenario life forms would still have to deal with radiation bombardment, but less so over time as the star moves out of its relatively short active phase. Solar flares could remain a hazard.

### Atmospheric problems

- Models of different kinds of mini-Neptunes with varied orbit eccentricity, masses and diameters. The researchers discovered that to be potentially habitable, a planet would need to be **no bigger than two or three Earth masses** to transform into a super Earth. Any bigger and the planet's stronger gravity would hold on to too much atmospheric pressure at the surface, even if it shields against radiation.

- A super Earth sized planet in this scenario may be the right size, but still suffer from challenges to habitability, as it likely will have a hydrogen or helium atmosphere, inhospitable to life as we know it.
- Some scientists believe Earth's atmosphere (mostly nitrogen and oxygen) formed later in the planet's geologic history from volcanic eruptions. Near a volatile M dwarf, however, a secondary atmosphere (atmosphere created after the planet was formed) could be stripped away just as quickly as the first.
- And if this hypothetical planet was mostly made of ice prior to migrating closer to the star, its closer and warmer location would form a **water world**, which **presents its own set of challenges**.
- Water worlds typically have no continents, and may lack a carbon cycle to fuel life.
- Meanwhile, the pressure from all the water could create high pressure ice at the bottom of the ocean, preventing minerals necessary for life from seeping out of the planet's interior.
- These worlds would be very different from Earth.

### Observing challenges

- Current technology can't spot such worlds well: too far out from their parent star, too small and dim.
- If a planet is too close to be habitable, it could be spotted through gravitational effects on its star.
- A new telescope might spot former mini-Neptunes. The TESS observatory (Transiting Exoplanet Survey Satellite) to be launched in 2017 will look at planets orbiting dwarf M-class stars if they exist.##.

## What Would It Be Like to Live on Alien Planet Kepler-186f?

9 May, 2015 – [www.space.com/29020-living-on-alien-planet-kepler-186f.html](http://www.space.com/29020-living-on-alien-planet-kepler-186f.html)

In recent years, NASA's Kepler space telescope and other observatories have discovered more than 1,800 extra-solar planets, with thousands of additional "candidate" planets awaiting confirmation.

### If you somehow wound up on an Earth-size alien world, what would you experience?

- In 2014 scientists announced the discovery of Kepler-186f — the first Earth-size exoplanet found in its star's 'habitable zone' where liquid water (therefore, life) could exist.
- Kepler-186f is about half the size and half the mass of the Sun, and dimmer than the Sun. However, the exoplanet is only 52.4 million km (32.5 million mi) from its sun, whereas Earth is 150 million km (93 million mi) from the sun.
- If you were standing on the surface of this exoplanet, Kepler-186 would appear about 30 % larger than the Sun appears from Earth, but Kepler-186f would receive slightly less light from its star than Earth does from the Sun. At high noon on a sunny day on Kepler-186f, Kepler-186 would look comparable to the sun an hour before sunset on Earth..
- What would sunrises and sunsets look like on Kepler-186f? That would depend on its atmosphere? With an Earth-like atmosphere, sunrises and sunsets would be more "enhanced" than Earth's because there would be overall less blue light coming from the star.
- Given the unknowns around Kepler-186f's atmosphere, it's also unclear what kind of weather or temperatures you would be experienced.
- Kepler-186f's surface features are also a mystery.
- Measurements suggest that Kepler-186f is 11% larger than Earth (in diameter? In mass?)
- It's not possible to pinpoint the exoplanet's gravity without knowing its composition. If the exoplanet were "rocky" like Earth (made up of one-third iron and two-thirds silicate rock, water and ice), its gravity would be similar to Earth's.
- Whereas Earth has a 365-day year, Kepler-186f takes 130 Earth days to orbit its star.
- The exoplanet is expected to have a nearly circular orbit around Kepler-186, so you probably wouldn't experience seasonal temperature differences due to its distance from its sun.
- But, like Earth, it may have seasons due to an axial tilt, affecting how much light different parts of the planet receive throughout the year.
- Scientists have not been able to ascertain Kepler-186f's day length, or if the planet is tidally locked with its star (with one side of the planet faces the star at all times).
- Kepler-186 system has four other own planets, all closer to their sun than Kepler-186f.
- These inner planets are all tidally locked with Kepler-186
- Models suggest Kepler-186f is far enough from its star that it might not be tidally locked with it.



- From the surface of Kepler-186f, the star's inner planets would be difficult to see.
- Kepler-186e could be visible by eye for a short time, such as during sunset, and it would look like a bright star, similar to what Venus looks like from Earth.
- If you wanted to try to contact people back home on Earth, don't hold your breath — a message sent from Kepler-186f would take almost 500 years to get to Earth. ##

## Renamed “Carl Sagan Institute for Pale Blue Dots” Will Search for Alien Life

9 May, 2015 - <http://www.space.com/29356-carl-sagan-alien-life-search-institute.html>

[Text “abridged” rather than “bulletized”]-

An institute dedicated to searching for alien life in the cosmos has been renamed in honor of the late astrophysicist and science popularizer Carl Sagan. Cornell University's “Institute for Pale Blue Dots” has been renamed “The Carl Sagan Institute: Pale Blue Dots and Beyond” to honor his legacy.

Empowering interdisciplinary scientists to search for the answers to Carl Sagan's most passionate scientific questioning, seeks to share that understanding with the public. Finding in that knowledge “applications to life-threatening dangers here on Earth”



Sagan was a faculty member at Cornell beginning in 1968, as the David Duncan Professor of Astronomy and Space Sciences and director of the Laboratory for Planetary Studies, until his death in 1996.

It was his widow, Ann Druyan, who not only inspired the name change, but directly requested it.

The institute was founded with the goal of taking an interdisciplinary approach to the search for life elsewhere in the universe. Researchers who have joined the institute have backgrounds in astrophysics, engineering, geology, biology and earth science,.

The institute is an umbrella facilitating this search so interested people can work together.

Currently, the institute is funding a small group of undergraduate and graduate students, and postdoctoral researchers. Faculty members who belong to the institute already have established positions at Cornell. There are plans to expand the institute's funding, and to bring in members from other institutions.

The institute has already produced a “color catalog” that could help scientists look for signs of life on alien planets. A planet that is dominated by a certain type of plant life or microorganism could have a distinct color signature that scientists could potentially observe.

Earth, for example, would have a green color because it is covered mainly by green plant life.)

The catalog, the first of its kind, contains color spectra for more than 100 different life-forms.

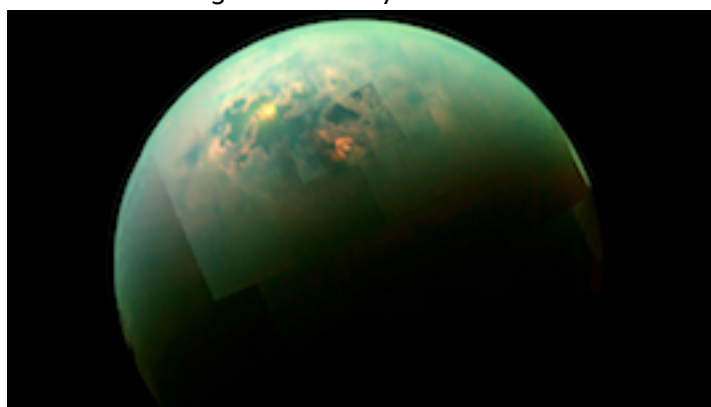
Pale Blue Dot” refers to the appearance of Earth from afar. It originated with a photograph of Earth taken Feb. 14, 1990, by the Voyager 1 space probe from a distance of about 5.95 billion km (3.7 billion mi) from Earth. Sagan further popularized the phrase with his book “Pale Blue Dot: A Vision of the Human Future in Space” (Random House, 1994). ##.

## Could Alien Life on Oily Exoplanets Have Ether-based 'DNA'

13 May, 2015 - [www.space.com/29389-alien-life-hydrocarbon-exoplanets-ether-dna.html](http://www.space.com/29389-alien-life-hydrocarbon-exoplanets-ether-dna.html)

In the search for life beyond Earth, scientists have justifiably focused on water because all biology as we know it requires water.

- But can alternative liquids can also suffice as life-enablers? For example, Saturn's frigid moon, Titan, is awash in inky seas of the hydrocarbon methane – a liquid at very low temperatures.
- Here on warm, watery Earth, the molecules DNA and RNA serve as the blueprints of life, containing creatures' genetic instruction manuals. An immense family of proteins carries out these instructions.
- In a hydrocarbon medium on Titan, these molecules could never perform these duties. Can other molecules do this service for non-water-based "alien" life forms, allowing them is to operate and evolve i with genetic changes leading to diversity and complexity.
- A new study proposes thatethers, not used in any genetic molecules on Earth, could fulfill the role of DNA and RNA on worlds with hydrocarbon oceans.
- Such worlds must be a good deal warmer than Titan for life-like chemistry to take place.
- The ether-based "DNA" proposed could perform on "warm Titans"
- Bigger molecular cousins to **methane**, such as the **octane** that helps fuel our vehicles, would also make for far more suitable solvents.
- No "warm Titans" around other stars have shown up so farl. But the search has just begun.
- Each week, astronomers are discovering new solar systems other than our own.



An artist's impression of the low-lit surface of Titan under the moon's thick, orange haze, with liquid hydrocarbons pooling and eroding the surface much like water on Earth.

- Within our own solar system, we do not have a planet big enough, close enough to the sun, and with the right temperature to support warm hydrocarbon oceans on its surface,
- But each week, astronomers are discovering new solar systems other than our own.

#### **A molecular sketch of life on Earth**

- On a fundamental level, the development of life on Earth has been a push-and-pull between molecules changing and staying the same.
- For an organism to reproduce and make copies of itself, the vast majority of its genetic information must be conserved if the offspring are to survive and still carry life forward.
- But if life does not change and adapt to inconstant environmental conditions, it will die out.
- Environmental curve balls to life include temperature swings, varying water and nutrient availability.
- Individual "letters," or nucleobases, in the four-letter code of DNA and RNA can mutate without destroying the molecule's overall form and function.
- These nucleobase changes can produce novel proteins, which in turn let life chemically interact with its environment in new ways to promote survival, as Charles Darwin surmised.
- New species arise in this manner, as fresh traits take hold in contrasting conditions and locations.
- The general structure, and therefore the general behavior, of DNA and RNA remains the same because of repeating elements in the chemical's backbone, or main scaffolding.
- **The molecules possess an outwardly negative charge that repeat along their backbones, which allows DNA and RNA to dissolve and float freely in water.**
- In this fluid medium, the DNA and RNA can interact with other biomolecules, leading to complexity in biological systems.
- "This is the central point of the 'polyelectrolyte theory of gene,' that any genetic biopolymer able to support operating in water must have an ever-repeating backbone charge.

- The repeating charges so dominate the physical behavior of the genetic molecule that any changes in the nucleobases that influence genetic information have essentially no significant impact on the molecule's overall physical properties."
- All of which is well and good for us water-based organisms.

### Waterless Worlds

- On waterless worlds like Titan where hydrocarbons reign, molecules like DNA and RNA wouldn't work.
- These biomolecules cannot dissolve in hydrocarbons to allow for life's microscopic bump-and-grind.
- "None of these molecules have any chance of dissolving in a hydrocarbon ocean like on Titan or on a warm Titan," said Benner.
- More bothersome still, molecules with any sort of outward charge goop up in hydrocarbons.
- The blueprints of Earth life contained in DNA and RNA can't translate to hydrocarbon-logged worlds.

### Enter the ether and ether-based life

- Compounds called ethers, when strung together form complex "polyethers," can likely perform in a manner that stays faithful to the polyelectrolyte theory of gene.
- Ethers, like DNA and RNA, have simple, repeating backbones, in their case of carbon and oxygen.
- Structurally, ethers do not have an outward charge, like DNA and RNA, but do possess internal charge repulsions that open up useful "spaces" within the molecules, wherein small elemental chunks can go that work like the DNA's and RNA's nucleobases.
- Experimenters tested out how well polyethers would dissolve in various hydrocarbons.
- The researchers further ran experiments at temperatures expected of Titan-esque worlds at different distances from host stars.
- Hydrocarbons, like water, can be solids liquids or gases, depending on temperature and pressure.
- As with the astrobiological hunts for water-based life, the liquid phase of hydrocarbons is the one of interest, because in solids (like ice), biomolecules cannot interact, and in gases (water vapor), the medium is too thin to support enough interaction.
- As a rule, the temperature range at which a hydrocarbon is a liquid goes up as the hydrocarbon becomes longer. Methane, the simplest, shortest hydrocarbon with a single carbon atom linked to four hydrogen atoms, has a very narrow liquid range—between about -300 and -280 °F.
- Inconveniently, the solubility of ethers plummets when getting down into these Titanian chills.

### Thua Titan looks like a very unlikely abode for aliens.

### Methane oceans at Titan are likely to be too cold to hold any genetic biopolymer.

- (Puzzling readings of less hydrogen and acetylene than expected at Titan's surface have, however, hinted previously at a form of microbial life.)

### Degrees of degrees- Propane may be a better medium, and Octane better yet

- A better bet for life than methane-ocean worlds are those instead covered by propane.
- This gaseous hydrocarbon has three carbon atoms to methane's one.
- It can stay liquid over a much broader chemistry suitable range of -184 to -40°C (-300 to -40 °F)
- Still better than propane is octane. This eight-carbon molecule does not freeze until about -57°C (-70 °F), nor does it turn into a gas until reaching a quite-hot 125°C (257°F).'
- That broad a range with sufficient ether solubility suggests that **warm Titans** could harbor a truly alien biochemistry capable of evolving complexity in a Darwinian manner.
- These worlds could be found in a fairly wide "hydrocarbon habitable zone" around other stars.
- The hydrocarbon habitable zone is akin to the familiar water-based zone, wherein a planet is neither too close nor too far from its star to have its water completely boil or freeze away.
- Hydrocarbon worlds need not be Titan-like, after all, in that they do not have to be moons of gas giants.
- Warm Titans could actually be more like oily Earths or super-Earths, drenched in octane.
- As research continues, new and exotic solvents other than water and hydrocarbons could yet emerge as plausible milieus for life's dealings.
- Virtually every star has a habitable zone for every solvent ##

## NASA Pluto Probe May Carry Crowdsourced Message to Aliens

19 May, 2015 - [www.space.com/29439-pluto-spacecraft-message-to-aliens.html](http://www.space.com/29439-pluto-spacecraft-message-to-aliens.html)

Check at the end of the PLUTO news section for this article

### OUR GALAXY – THE “MILKY WAY”

## Giant Radio Telescope Peels Away Magnetic Field Shrouding Black Hole

16 April, 2015 - [www.space.com/29122-black-hole-magnetic-field-alma-telescope.html](http://www.space.com/29122-black-hole-magnetic-field-alma-telescope.html)

Astronomers have peeled away most of the gas and dust enshrouding a monster black hole, taking a close look at the giant that lies some 68 thousand light-years away.

- Swedish scientists has used the Atacama Large Millimeter/submillimeter Array (ALMA) — a huge radio telescope in Chile to unmask a supermassive black hole's extremely powerful magnetic field.



**Left:** artist concept of black hole



**Right:** part of the ALMA complex

- The team was able to peer deep into the heart of the distant galaxy where the black hole lies, and see the region just light-days away from the behemoth.
- The discovery is a giant leap in terms of observing frequency and in terms of distance to the black hole where the magnetic field has been probed.
- Supermassive black holes loom in the centers of the majority of massive galaxies. Some of these black holes, like the one in the Milky Way's center, lie dormant.
- Others (so-called “quasars”) actively chow down on gas, causing them to radiate like brilliant beacons of light. They can therefore be seen from across the universe.
- Although these monsters clearly accrete huge amounts of matter, some material escapes.
- It's flung out into space at close to the speed of light in a jet of plasma.
- Astronomers don't understand the physical mechanism at play here, but think it has to do with a strong magnetic field close to the black hole itself.
- Luckily, magnetic field lines leave an imprint on any light that passes through them, twisting the light so that it is circularly polarized, meaning the electric and magnetic fields rotate continuously as the wave moves, in a corkscrew motion.
- The stronger the magnetic field, the stronger this imprint.
- Until now, only weak magnetic fields located several light-years from the black hole have been caught on camera via this twisting of light.
- By looking at higher energies, like the ones visible with ALMA, astronomers can probe more powerful magnetic fields, which lie closer to their black hole counterparts.
- These results, and future studies, will help us understand what is really going on in the immediate vicinity of supermassive black holes. ##



## Size of the Milky Way Upgraded, Solving Galaxy Puzzle

4 May, 2015 – [www.space.com/29270-milky-way-size-larger-than-thought.html](http://www.space.com/29270-milky-way-size-larger-than-thought.html)

**A new study show that the Milky Way's disk is about 60% larger than previously thought.**

- Not only do the results extend the size of the Milky Way, they also reveal a rippling pattern, which raises intriguing questions about what sent **wavelike fluctuations rippling through the disk.**



The disk of the Milky Way Galaxy disk may actually be rippled  
**Two ringlike structures of stars wrapped around the Milky Way's outer disk may belong to the disk itself.**

- The likely culprit appears to be a dwarf galaxy that might have plunged through the Milky Way's center long ago, sparking the rippling patterns astronomers have now detected for the first time.
- Roughly 15 years ago, Heidi Newberg, an astronomer at the Rensselaer Polytechnic Institute in New York, and her colleagues found a group of stars beyond the disk's outermost edge. The so-called "**Monoceros Ring**" is about 60,000 light-years from the galactic center (just beyond where the disk was thought to end at 50,000 light-years).

### Prior Speculation

- Over the years, astronomers were divided into two camps regarding the origins of the ring. Was it **simply a tidal stream**? Was it **the debris of a dwarf galaxy** that fell into the Milky Way and got stretched in the process? Others argued that the ring is a part of the disk.
- The issue, however, is that the ring is slightly above the plane of the disk. So some astronomers attributed that to the fact that the disk flares up toward the edge.

**Yan Xu, an astronomer at the National Astronomical Observatories of China. Xu and colleagues took a second look at the problem using data from the Sloan Digital Sky Survey.**

- With improved data compared to previous studies, they found **four total structures in and just outside** the Milky Way's outer disk. The third structure was the highly debated Monoceros ring, and the fourth structure was the Triangulum Andromeda Stream, located 70,000 light-years from the galactic center.
- All four structures alternated with respect to the disk, going from above it to below it..
- It came as a surprise to many that the ring and three other structures were actually a part of an oscillating disk. They did not know how a disk could go up and down.
- Luckily, computer simulations by various teams showed that a dwarf galaxy falling into the Milky Way might create a similar pattern. As it passes through, it could disturb the disk just like a pebble disturbs water in a puddle, and that wave can propagate through the disk from that event on.
- Not only does this new picture make sense, it even matches observations of the gases in the disk, which have long been observed as rippled.

**The implications extend far beyond a corrugated, rippling disk.**

- If the Monoceros Ring and the Triangulum Andromeda structure are part of this oscillatory pattern, then the stellar disk goes out way further than the current textbook descriptions.
- Instead of extending nearly 100,000 light-years from one side to the other, **The Milky Way is more like 160,000 light-years wide.**

- **This brings the Milky Way's size up to that of M 31, the famed Andromeda Galaxy.** The Milky Way's small radius in comparison to Andromeda's larger radius has always puzzled astronomers, because **the two galaxies have roughly the same mass.**
- The team plans to further map our galaxy's rippled disk to better match their results to models.##

## Black Holes Might Make Dark Matter Shine

14 May 2015 – [www.space.com/29382-black-holes-make-dark-matter-shine.html](http://www.space.com/29382-black-holes-make-dark-matter-shine.html)

[ This is some wild "if there is a will, there is a way" stuff ]



An artist's concept shows a black hole eating material from a nearby star.

Researchers say its possible dark matter swirling around a black hole could radiate gamma rays that could be seen by telescopes.

- Dark matter circling the drain of a massive black hole **could radiate gamma-rays** that might be visible from Earth,
- Dark matter is five times more plentiful in the universe than regular matter, but it does not emit, reflect or absorb light, making it not just dark but entirely transparent.
- But if dark-matter particles around black holes can produce gamma-rays (high-energy light), such emissions would give scientists a new way to study this mysterious material.
- The process responsible for creating the gamma-rays is somewhat counterintuitive, because it seems to defy two common assumptions: that nothing can escape from a black hole and that there's no such thing as a free lunch.

### Improbable escape

- Jeremy Schnittman, a theoretical astrophysicist at the NASA Goddard Space Flight Center, is beginning a project to look through data from the **Fermi Gamma Ray Space Telescope** for signs of high-energy light around the edge of a black hole that might have been created by dark matter.
- Schnittman's search for this dark-matter signal began with a computer program that he has been developing for about 10 years. It models in 3D the paths of particles as they zip through space near a black hole, while some of them get close enough to orbit around the black hole or fall in.
- Just over a year ago, he decided to adjust the program to model dark-matter particles. The resulting video shows how the subatomic bits get caught up in the gravitational pull of the black hole and swirl around it in a region called the ergosphere (where all particles must orbit in the direction of the black hole's spin). Some of the particles collide and annihilate each other producing a pair of gamma-rays.
- These particles of light might normally fall into the black hole, helpless against its gravitational pull, were it not for something called the Penrose process.
- In 1971, astrophysicist Roger Penrose showed that if two photons are created very close to a black hole, it's possible for one of them to escape, while the other falls in – counter to the commonly held idea that nothing that goes past the "event horizon can escape from a black hole.,
- According to the Penrose principle, the particles are not created beyond this point of no return, but under normal circumstances, it's unlikely that either particle would have any means of getting away from the black hole.
- The Penrose process still changes the fate of at least one particle, giving it an escape route.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/)

and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- In 2009, a group of researchers showed that If dark-matter particles are annihilating near the surface of a black hole, telescopes on Earth could detect the escaping gamma-rays.
- Schnittman's work using the 3D computer model has shown **many more paths that the particles can take, including some that are more likely to produce gamma-rays that can escape the black hole**, and with even higher energies than had been previously predicted.
- A brief description of those results was published in the journal Physical Review Letters last December, and a longer description of the work has been accepted to the Astrophysical Journal.
- With those results, Schnittman and colleagues are now looking for this signal, although they expect it to be very dim compared to many other gamma ray sources.
- They are creating a list of target galaxies with few gamma-ray sources and very massive black holes.
- "The bigger the black hole, the bigger the signal," It scales in a way that as your black hole [mass] goes up by a factor of 10, the expected signal goes way up, by something like a factor of 1,000.
- "The first pass at observing this effect is almost certainly not going to yield an actual detection.
- But it will provide probably the strongest upper limit on this type of process that has ever been seen before — the idea of high-energy dark-matter particle reactions.

## OTHER GALAXIES

### Colossal Ancient Galaxies Die from the Inside Out

16 April, 2015 - <http://www.space.com/29123-ancient-galaxies-die-inside-out.html?>



The elliptical galaxy IC 2006 as seen by the Hubble Space Telescope.

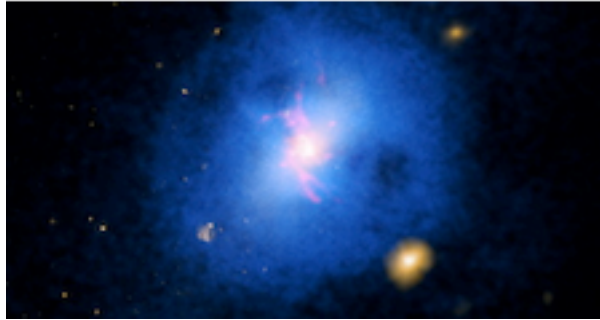
A new study suggests that the most massive elliptical galaxies **stopped star formation near their centers roughly three billion years after the Big Bang**

- The largest ancient galaxies stopped forming stars in their cores about three billion years after the Big Bang, with this end of star birth spreading from the inside out in so-called "dead" galaxies.
- A new survey of 22 elliptical galaxies (most of which were the same size or larger than our own Milky Way) revealed that the most massive galaxies from about 10 billion years ago have stopped forming stars in their centers while formation continued on the outskirts.
- These galaxies lived 10 billion years in the past — three billion years after the Big Bang — and are still star-forming at high rates
- The survey of ancient elliptical galaxies adds fuel to an ongoing debate about how the star shutdown occurs. One leading theory is that a supermassive black hole drives gas out, disrupting star formation, The other theory is an as yet-unexplained mechanism switching off the gas supply in the center.
- Data from his study would support either of these two contentions, or even a combination of the two. Also interesting was the smaller, elliptical galaxies from this era were still churning out stars throughout their masses. Why is still poorly understood.
- The smaller galaxies are doubling their mass at the same pace in their inner and outer parts.
- This same phenomenon was observed in younger galaxies closer to us. ##

## 'Cosmic Precipitation' Can Extinguish Star Formation in Galaxies

9 April, 2015 – [www.space.com/29055-cosmic-precipitation-star-formation-black-holes.html](http://www.space.com/29055-cosmic-precipitation-star-formation-black-holes.html)

Massive galaxies may not form nearly as many stars as possible due to "cosmic precipitation"



Abell 2597 is a galaxy cluster located about 1 billion light-years from Earth. A survey of galaxy clusters like this one suggests that star formation can be limited by a form of cosmic precipitation.

**When interstellar gas cools rapidly, it condenses and collapses to form new stars.**

- All massive galaxies are powered by a central supermassive black hole, which can easily spew out high-energy radiation, heating the gas and halting star formation.
- Astronomers have long suspected this, but did not know what causes this super hole to erupt.
- The new study links the black hole's eruptions to the initial state of the interstellar gas.
- When gas cools enough to ignite star formation, those cold clouds rain down ("cosmic precipitation") onto the black hole, triggering high-energy jets that heat the gas and halt star formation.

**It all comes down to temperature.**

- Several years ago, astronomers recognized that **in galaxies where the black hole was dormant, the surrounding gas was intensely hot.**
- In galaxies with an active black hole, the surrounding gas was more varied and even cool.
- Some galaxies are simply too hot to affect their black hole. Even if one region starts to cool, the intensity of the surrounding heat would keep it from cooling further.
- In cooler galaxies, however, the gas near the central black hole might be cold enough to form stars.
- Before it can form too many, the cool gas cloud rains down onto the supermassive black hole, which then triggers energetic jets that reheat that cool gas cloud and prevents any stars from forming.
- A typical weather forecast for a massive galaxy center: "cloudy with a chance of heat from a huge black hole."
- The team observed 200 massive galaxies in the middle of galaxy clusters using the Chandra X-ray Observatory and the South Pole Telescope.
- They found that these two mechanisms regulate star formation depending on whether a galaxy is above or below a certain temperature threshold.
- For clusters significantly above that threshold, any pockets of cold gas will quickly be reheated by their surroundings.
- The team's next results are currently in the referee process, but should be published soon. ##

## A Cold Cosmic Mystery Solved

24 April, 2015 – [www.spacedaily.com/reports/A\\_cold\\_cosmic\\_mystery\\_solved\\_999.html](http://www.spacedaily.com/reports/A_cold_cosmic_mystery_solved_999.html)

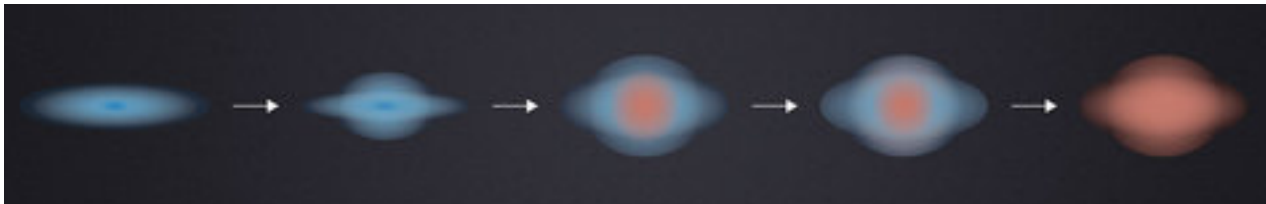
In 2004, astronomers examining a map of the radiation leftover from the Big Bang (**cosmic microwave background**, or **CMB**) discovered the Cold Spot, a larger-than-expected unusually cold area of the sky.

- The physics surrounding the Big Bang theory predicts warmer and cooler spots of various sizes in the infant universe, but a spot this large and this cold was unexpected.
- A team of astronomers at the Institute for Astronomy at U.of Hawaii at Manoa may have found an explanation for the existence of the Cold Spot, perhaps "the largest individual structure yet identified.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



- If the Cold Spot originated from the Big Bang itself, it could be a rare sign of exotic physics that the standard cosmology (the Big Bang theory and related physics) does not explain.
- If, however, it is caused by a foreground structure between us and the CMB, it would be a **sign that there is an extremely rare large-scale structure in the mass distribution of the universe.**
- Using data from Hawaii's Pan-STARRS1 (PS1) telescope located on Haleakala, Maui, and NASA's Wide Field Survey Explorer (WISE) satellite, a team discovered a **large supervoid, a vast region 1.8 billion light-years across, where the density of galaxies is much lower** than usual in the known universe.
- This void was found by combining observations by PS1 at optical wavelengths with observations by WISE at infrared wavelengths to estimate the distance to and position of each galaxy in that area.
- Earlier studies, also done in Hawaii, observed a much smaller area in the direction of the Cold Spot, but they could establish only that no very distant structure is in that part of the sky.
- Paradoxically, **identifying nearby large structures is harder than finding distant ones**, since we must map larger portions of the sky to see the closer structures.
- The large 3-dimensional sky maps created from PS1 and WISE were thus essential for this study.
- The supervoid is only c. 3 billion light-years away, relatively near in the cosmic scheme of things.
- Imagine there is a huge void with very little matter between you (the observer) and the CMB. Now think of the void as a hill. As the light enters the void, it must climb this hill.
- If the universe were not undergoing accelerating expansion, then the void would not evolve significantly, and light would descend the hill and regain the energy it lost as it exits the void. But with the accelerating expansion, the hill is measurably stretched as the light is traveling over it.
- By the time the light descends the hill, the hill has gotten flatter than when the light entered, so the light cannot pick up all the energy it lost upon entering the void. The light exits the void with less energy, and therefore at a longer wavelength, which corresponds to a colder temperature.
- Getting through a supervoid can take millions of years, even at the speed of light, so this measurable effect, known as the Integrated Sachs-Wolfe (ISW) effect, might provide the first explanation one of the most significant anomalies found to date in the CMB, first by a NASA satellite called the Wilkinson Microwave Anisotropy Probe (WMAP), and more recently, by Planck, an ESA satellite.
- While the existence of the supervoid and its expected effect on the CMB do not fully explain the Cold Spot, it is very unlikely that the supervoid and the Cold Spot at the same location are a coincidence. The team will continue its work using improved data from PS1 and from the Dark Energy Survey being conducted with a telescope in Chile to study the Cold Spot and supervoid, as well as **another large void located near the constellation Draco.**



This graphic shows how star formation stops in the heart of an elliptical galaxy, then spreads out to the outermost edges to create a so-called "red and dead" galaxy.

### Solving the mystery

- Figuring out what stopped the star formation in these massive galaxies will require more observations.
- These "red and dead" elliptical galaxies contain a lot of old, dead red stars, but fewer blue youngsters.
- The study of 22 galaxies ate up 300 hours of observing time between the Hubble Space Telescope and the European Southern Observatory's Very Large Telescope in Chile.
- The VLT looked at the spectra (light distribution) of stars, showing where the young ones were.
- Hubble was used to trace the older stars, showing the stellar mass distribution of galaxies.
- The sheer amount of time would be difficult to replicate given the high observing time demands on these observatories.
- In a further, focused study, Hubble will look at the star formation habits of the 10 largest galaxies.
- Better resolution will soon be available to astronomers as well as new observatories come online that can peer further back in time to galaxies that formed closer to the Big Bang. ##

## Gravitational 'Slingshot' May Have Flung Runaway Galaxies Far, Far Away

1 May, 2015 – [www.space.com/29284-runaway-galaxies-gravitational-slingshot-discovery.html](http://www.space.com/29284-runaway-galaxies-gravitational-slingshot-discovery.html)

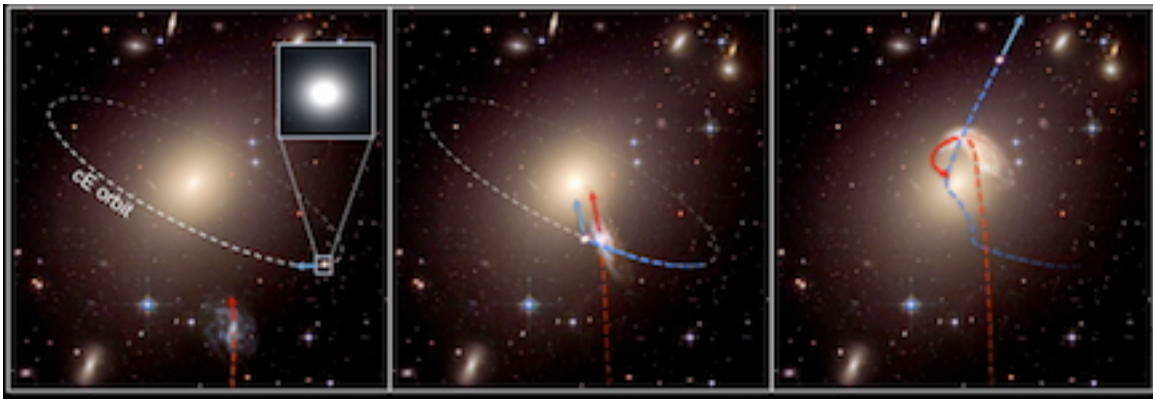
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Rare **loner galaxies** millions of light-years away from any neighbors may be runaways from violent, disruptive relationships with other galaxies.

Runaway objects are common in space. There may be **billions of runaway planets** in the Milky Way — rogue worlds” not gravitationally bound to any star. Moreover, scientists know of about two dozen runaway stars that escaped from the Milky Way at high speeds, and even one runaway cluster of about a million stars that fled the giant galaxy Messier 87 about 53.5 million light-years from Earth.

Now, researchers have discovered what appear to be 11 runaway galaxies. These small galaxies face a lonely future, exiled from galaxy clusters they were formed in and used to live in. The scientists focused on rare galaxies known as compact ellipticals that resemble the centers of regular oval-shaped elliptical galaxies.

Only a few hundred light-years in diameter, compact ellipticals are equal in weight to about a billion suns, making them about 100 times **less massive** than the Milky Way.



This schematic illustrates the creation of a runaway galaxy. **Left:** an “intruder” spiral galaxy approaches a galaxy cluster center, where a compact elliptical galaxy already revolves around a massive central elliptical galaxy. **Center:** a close encounter occurs and the compact elliptical receives a gravitational kick from the intruder. **Right:** the compact elliptical escapes the galaxy cluster while the intruder is devoured by the giant elliptical galaxy in the cluster center.

- Prior research found only about 30 compact ellipticals, such as Messier 32, orbiting the M31, the great nearby Andromeda galaxy.
- These compact ellipticals were found mostly near giant galaxies in the centers of large clusters of galaxies. These compact ellipticals might be the remnants of larger galaxies that had most of their stars stripped away from them by the gravitational attraction of neighboring galaxies, until they were only about a hundredth of their original mass.
- Previous studies found two compact ellipticals that were far away from any massive galaxy, raising the question of how they might have formed without larger partners to steal their material.
- To find out more about isolated compact ellipticals, researchers mined a huge amount of astronomical [data](#) publicly available due to the Virtual Observatory initiative, including data from the Sloan Digital Sky Survey and NASA's GALEX spacecraft.
- In addition to the 30 compact ellipticals detailed in previous studies, researchers have now discovered 195 more compact ellipticals – an unexpected result.

### Isolated Runaway Galaxies

- The scientists looked for compact ellipticals both within clusters and groups of galaxies, and between them. As expected, most of these compact ellipticals were found inside massive clusters and groups of galaxies. However, 11 were isolated, located millions of light-years from their nearest clusters.
- Researchers suggested that compact ellipticals were victims of “galactic threesomes” — a massive galaxy initially tore away their outer parts, leaving only their cores, and later, some other galaxy flung these cores away.

- Similar activity is known to happen near the center of the Milky Way — a supermassive black hole can hurl away one of two stars in a binary system that came too close to it, and swallow the other star.
- This is the same phenomenon but working on a different scale — a slingshot effect — when, during a three-body encounter, the lightest body flies away from the system.
- So far, this is the largest scale on which a gravitational slingshot effect has been shown to work.
- Researchers analyzed the velocities of compact ellipticals in galaxy clusters and found that many were on the verge of “running away.” To escape the Earth, a cosmic body must travel faster than 24,600 mph (39,600 km/h), and to escape the solar system from Earth's orbit, an object must travel more than 93,950 mph (151,200 km/h). But for a compact elliptical to escape its cluster, it would have to travel about 9 million km/h (5.6 million mph), the researchers calculated.
- Although compact ellipticals may face a future of solitude in the void of intergalactic space if they stayed in their home clusters, they would probably get devoured by their massive neighbors in about a billion years. Life might actually be surprisingly calm on such disrupted galaxies.
- If there are planetary systems in the central region that remained in the galaxy after the tidal stripping event, there will be virtually nothing happening. Any stars in these compact ellipticals will likely be tightly packed, so the sky on such a planet will be full of stars comparable to Venus by brightness. But since all these stars are old, there will be no risk of destructive close supernova explosions.
- Any stars in the skies of such worlds likely would be older, and thus bright yellow or bright red.
- Next, researchers hope to use the 6.5-m (21 ft) Magellan telescope in Chile to study the dark matter within compact ellipticals. They should have had much of their dark matter stripped, influencing their structure and evolution, as dark matter's gravitational pull helps keep many galaxies stable.
- We shouldn't find any dark matter in them. If we do, it will call for explanations.”
- Chilingarian and Zolotukhin detailed their findings online April 23, 2015 in the journal **Science**.##

## This Galaxy Far, Far Away Is the Farthest One Yet Found

5 May, 2015 – [www.space.com/29319-farthest-galaxy-ever-found.html](http://www.space.com/29319-farthest-galaxy-ever-found.html)

A galaxy far, far away — farther than any other known galaxy — has been measured.

- The galaxy EGS-zs8-1 lies 13.1 billion light-years from Earth, the largest distance ever measured between Earth and another galaxy. The universe is thought to be about 13.8 billion years old, so galaxy EGS-zs8-1 is also one of the earliest galaxies to form in the cosmos.
- Further studies could provide clues to **how these early galaxies helped produce the heavy elements that are essential for building the diversity of life and landscapes we see on Earth today.**
- EGS-zs8-1 is one of the brightest objects observed in this region, c. 13 billion light-years from Earth.
- Authors of the new research say other galaxies likely lie at similar distances or even further from Earth, but they are too faint for scientists to measure their exact distance.
- A lot of sources that we can see with Hubble are probably farther away than EGS-zs8-1.
- How quickly those objects are moving away from Earth fits the rate at which the universe is expanding, growing like a balloon, as large scale objects in the universe move away from each other.
- As these objects move away from Earth, the light they emit becomes shifted. The more far-flung an object is, the faster it appears to move away from Earth, and the more the light is shifted.
- So, by measuring the degree of shifting — the “redshift” — astronomers can also measure distance.
- A higher redshift indicates a larger distance. Galaxy EGS-zs8-1 has the highest redshift ever measured, according to the new research (the previous record holder has a redshift only slightly smaller).
- Galaxy EGS-zs8-1 was first identified by the Hubble Space Telescope and the infrared Spitzer Space Telescope. It stood out because of the unique colors it emitted. This research used observations conducted with the MOSFIRE instrument on the Keck Observatory's 10-m (33 ft) telescope in Hawaii.
- The light from EGS has traveled 13.1 billion LY, so we see EGS-zs8-1 as it was 13.1 billion years ago.
- Then, the universe was only about 670 million years old, about 5% its current age of c. 3.8 billion years. The first stars began forming about 200 to 300 million years after “the Big Bang.”
- By combining observations from Keck, Spitzer and Hubble, the researchers say they can estimate that the stars in EGS-zs8-1 are “between 100 and 300 million years old.”

- But it is difficult to know how old EGS-zs8-1 is compared to other galaxies at a similar distance from Earth. It is, however, one of the oldest galaxies yet measured.
- The new observations also show that EGS-zs8-1 is forming stars 80 times faster than the Milky Way. This still-growing young galaxy has already more than 15% of the mass of our own Milky Way today.
- The unique colors observed in EGS and other early galaxies present questions about what took place in these primeval environments. These colors could have been caused by the rapid formation of massive, young stars that interacted with the primordial gas in these galaxies..
- Further study of EGS-zs8-1 could reveal the types and amounts of heavy elements formed there.
- By looking at different galaxies as a function of time, we can reconstruct the build-up of the heavy elements that we see around us today and that we're all made of. "
- In addition, the new observations provide "an indication of how the stars were forming at these extreme distances and earliest epochs, and they seem to be forming differently than the local universe.
- Every discovery opens up a whole new set of questions ##

## NASA's WISE Spacecraft Discovers Most Luminous Galaxy in Universe

[www.nasa.gov/press-release/nasas-wise-spacecraft-discovers-most-luminous-galaxy-in-universe](http://www.nasa.gov/press-release/nasas-wise-spacecraft-discovers-most-luminous-galaxy-in-universe)

21 May 2015 – A remote galaxy shining with the light of more than 300 trillion suns has been discovered using data from NASA's Wide-field Infrared Survey Explorer (WISE). The galaxy is the most luminous galaxy found to date and belongs to a new class of objects recently discovered by WISE -- **extremely luminous infrared galaxies, or ELIRGs.**

- "We are looking at a very intense phase of galaxy evolution, l.
- This dazzling light may be from the main growth spurt of the galaxy's black hole.
- "WISE J224607.57-052635.0," may have a behemoth black hole at its belly, gorging itself on gas.
- Supermassive black holes draw gas and matter into a disk around them, heating the disk to roaring temperatures of millions of degrees and blasting out high-energy, visible, ultraviolet, and X-ray light.
- The light is blocked by surrounding cocoons of dust. As the dust heats up, it radiates infrared light.
- Immense black holes are common at galaxy cores, but one this big so "far back" in the cosmos is rare.
- Because light from the galaxy hosting the black hole has traveled 12.5 billion years to reach us, astronomers are seeing the object as it was in the distant past.
- The black hole was already billions of times the mass of our sun when our universe was only a tenth of its present age of 13.8 billion years.
- The new study outlines three reasons why the black holes in tELIRGs could have grown so massive.
- They may have been born big, their "seeds," or embryonic black holes, bigger than thought possible.
- The other two explanations involve either breaking or bending the theoretical limit of black hole feeding, called the Eddington limit. When a black hole feeds, gas falls in and heats up, blasting out light. The pressure of the light actually pushes the gas away, creating a limit to how fast the black hole can continuously scarf down matter.
- If a black hole broke this limit, it could theoretically balloon in size at a breakneck pace. Black holes have previously been observed breaking this limit; however, the black hole in the study would have had to repeatedly break the limit to grow this large.
- Alternatively, the black holes might just be bending this limit.
- Another way for a black hole to grow this big is for it to have gone on a sustained binge, consuming food faster than typically thought possible, This could happen if the black hole isn't spinning that fast.
- If a black hole spins slowly enough, it can gobble up more matter than a fast spinner.
- "The massive black holes in ELIRGs could be gorging themselves on more matter for a longer period of time – hundreds of millions of years."
- More research is needed to solve this puzzle of these dazzlingly luminous galaxies.
- The team has plans to better determine the masses of the central black holes. Knowing these objects' true size will help reveal their history, as well as that of other galaxies, in this very crucial and frenzied chapter of our cosmos.
- WISE has been finding more such oddball galaxies in infrared images of the entire sky in 2010.



- By viewing the whole sky with more sensitivity than ever before, WISE has been able to catch rare comic specimens that might have been missed otherwise.
- The new study reports a total of 20 new ELIRGs, including the most luminous galaxy found to date.
- These galaxies were not found earlier because of their distance, and because dust converts their powerful visible light into an incredible outpouring of infrared light.
- As many as half of the most luminous galaxies only show up well in infrared light," said Tsai.
- The technical paper is online at: <http://arxiv.org/abs/1410.1751> ##

## Announcing A New International Moon-focused chapter of the National Space Society



### Getting Going Moonwards

By Kim Holder

**Moonwards, a special Interest Chapter of the National Space Society** is being set up. Its purpose is "to advance settlement of the Moon by giving the public a sense of what it would be like to live there, and what it could mean."

We have ways to do that now that give a whole new scope to the endeavor. These are the days of World of Warcraft, Minecraft, Eve Online. Moonwards principal project will be to create a virtual Moon colony, and make it as real as possible. It will be a plausible, viable Moon settlement, as it could be in a few decades if energy was put into creating one. It will be true to the reality, to the science. It will start as a digital model sited in an accurate depiction of a particular place on the Moon.

And it will grow from there.

There are so many ways it could grow with time. There are so many fans of space settlement out there who have skills that would make it an engaging, fun, rich place to be online. Bring us your ideas and energy, and let's make it a springboard into the future. Let us show the world what space can be.

If you would like to participate, please send an email to [nssmoonwards@gmail.com](mailto:nssmoonwards@gmail.com).

Watch for the launch of [www.moonwards.com](http://www.moonwards.com), where you can find out more.

The Chapter will be International, with members in the United States, Mexico, and Canada = for a start.

**Kim Holder** lives part time in **Mexico**, part time in **Canada**

**Initial U.S. Members** will include **Peter Kokh**, Editor of Moon Miners' Manifesto, **Dave Dunlop**, frequent contributor to To The Stars and chair of the National Space Society's International Committee, and **Al Alzandua**, of the Phoenix chapter (NSS/Mon Society.)

Kim Holder can be reached at: [kimholder@gmail.com](mailto:kimholder@gmail.com)

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TTSIQ is a project of the National Space Society's International Committee



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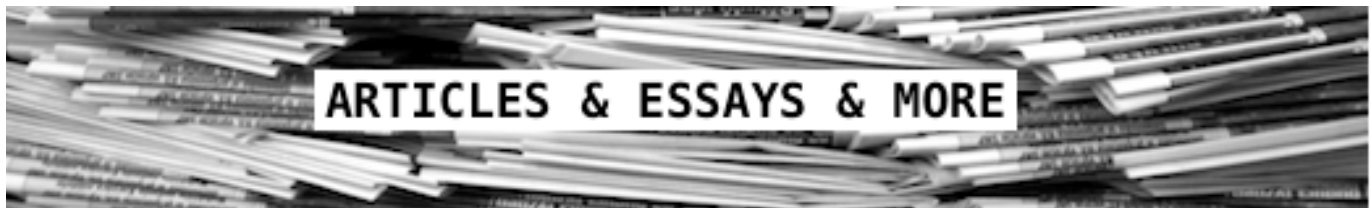
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The TTSIQ editorial team consists of persons of various backgrounds who are free t

**We welcome additional co-Editors and Contributors**  
**As well as Reporters from various nations and student groups**



## “Reimagining” Public Conceptions of Moon & Mars Bases & Outposts

By Peter Kokh

When it comes to public outreach, it is hard to think of something more important than changing common public conceptions of future human presence on the Moon and/or on Mars that comes from so many illustrations which ignore the need to shield our habitats on both worlds from the hazards of cosmic radiation, as well as from occasional meteorites large enough to puncture the walls of exposed pressurized structures.

Shielding also helps keep interiors at comfortable temperatures, particularly on the Moon where there is such a big temperature swing between two weeks of constant sunlight

Decades ago, NASA paid attention to shielding needs (example) but that was when in the Apollo years the plan was to stay on the Moon, and develop permanent outposts

Now NASA hopes someday it can put up a permanent shelter (from micrometeorites) but without shielding as they don't think these shelters will be continuously occupied, just visited now and then.

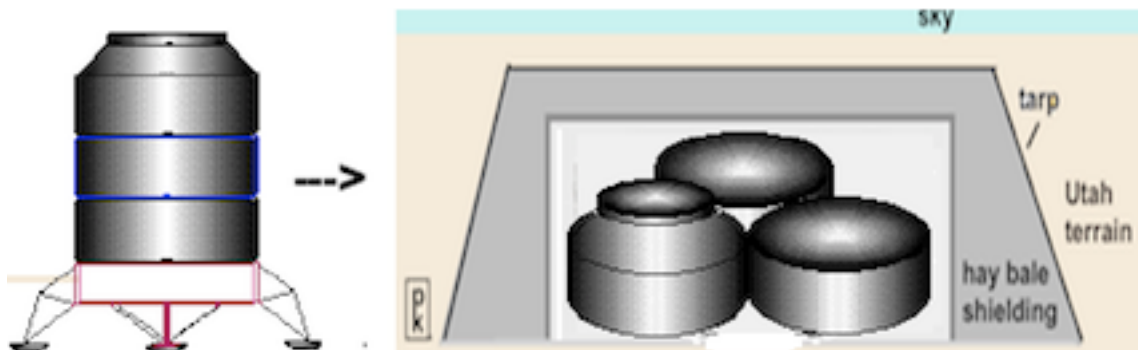
The scaling back of NASA's visions of the future is rooted in lack of government support and funds. Meanwhile the public is misled about the possibilities and the requirements necessary to make them real. It is time to reimagine public conceptions about Moon and Mars “Outposts” and “Settlements,” That is the mission we must sell to artists and modelers. Our publications should nix incoming illustrations which ignore the need for shielding.

### The Mars Society's two “Habs” on Devon Island and in southern Utah

Robert Zubrin's conception of a minimal early Mars outpost was based on transport restraints: 2 or 3 “tuna-can” floors on top of one another for ease of transit. **But if we want to shield them, it would be best to design the analog facilities as three one floor units, stacked on top of one another for transport, then set next to one another in a triangular one floor arrangement – for ease of piling” Mars” soil on top for **shielding from radiation** as well as for **minimizing external temperature swings**.**

And doing just that on Devon Island and in Utah, then shielding them, could extend crew-occupied “seasons” simply by moderating temperatures. That translates to more research per year.

That the Bureau of Land Management would not allow substantial soil movement at the Utah location would not stop using  $\sqrt$  **straw bales** as shielding, **covered with tarp** to prevent rain-soaking, and then **painting the tarp to mimic the ruddy soil**. With that form of at least minimal insulation, the crew seasons at both locations could be extended into summer and winter seasons.



**“Tri-stack” rearranged side-by-side . Thermal Insulation by hay bales, tarp and local soil. Is it too late, 14 years later? No! Will it cost? YES, but this improvement project will re-enthuse followers to contribute both the needed funds and needed manpower.**

The real problem, is that the original 2-floor units were not built to be “unstacked.” Does this mean that it can't be done? No. It will require some thinking. There is nothing more motivating to an engineer or architect than a real “can't do” challenge.

Well planned, it could be done in the off-season, one station at a time. Meanwhile, a third unit would allow for less cramping, and to the support of additional functions of a Moon/Mars base that have not been modeled in either of the Mars Society's two locations.

This project, if the Society is up to it, should attract new members to the Society, and possible support from the National Space Society as well, in exchange for one or two crew slots per season.

Creation of an FMARS/MDRS Crew "Alumni/Veterans" group would also revivify the project.

There does not seem to be anything to lose, and quite a bit to gain, public interest and enthusiasm being the top prize. Showstoppers? Let us know and we'll vaporize them! PK

## Mars is so boringly "monochromatic" – Opticians to the Rescue?

By Peter Kokh



**Unfortunately, these rocks are not really blue.**

Some optics manipulations with boringly monochromatic Marscape hues results in shifting hues of rocks of various kinds so that they stand out against the background, all for the sake of easier scientific examination.

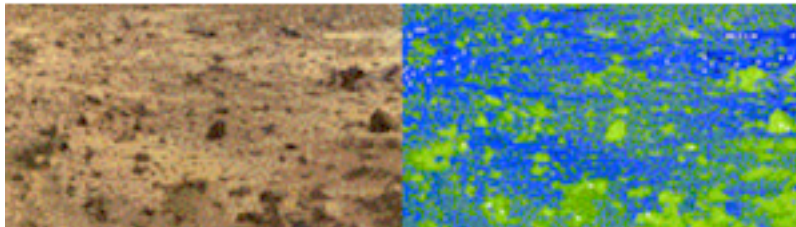
[www.theatlantic.com/technology/archive/2012/08/why-are-there-blue-rocks-in-the-latest-photos-from-mars/261149/](http://www.theatlantic.com/technology/archive/2012/08/why-are-there-blue-rocks-in-the-latest-photos-from-mars/261149/)

Of course it would be nice if these were the true colors. Then lamp bases, tablewear, and many other objects carved from such rocks or forged from powdered rock would become a mainstay of "traditional" Mars pioneer "early settlement" decor. But that seems unlikely. So what can we do?

Here is a suggestion. Make eyewear, including contact lenses, that produces this same color shift for residents and tourists alike, both out on the surface and inside frontier homes. Humans like variety and the monochromatic appearance of both the lunar and Martian terrain is certain to very soon bore to death immigrants and visitors alike, with a negative effect on morale and life satisfaction.

["The light from the sun as filtered through the dusty Martian atmosphere makes everything look red to your eye." "When we take our images and have uncorrected images, there's a little less contrast in the ground. The shadows aren't dark. There is a lot of diffuse light in the air.

"When we correct for Earth sunlight, you get a lot more contrast."]



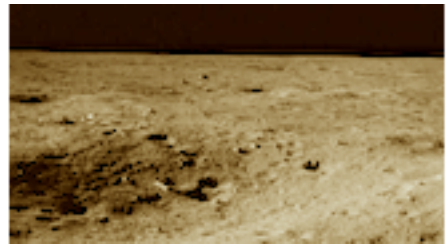
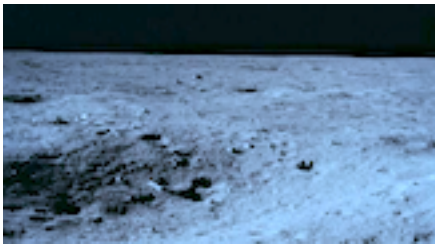
Above a Mars landscape in true colors **left**, and in exactly opposite colors, **right**  
**Can we play with optics eyewear so that some types of rocks look green and yellow?**  
**Opticians of the world, you can come to the rescue of the Martian pioneers! We hope!!**

**Applications for the Moon:: Eyewear that subtly "colorizes" the Moonscapes**

Now how do we do the same on the Moon? Create eyeglasses to use out on the Moon's surface that take subtle, unnoticeable color hues and magnify them to "colorize the moonscapes?"

Sure some NASA people might have a clue. If not, we can surely produce results shown below.





Left to Right: Blue hues

Natural hues

Warm Marslike hues

Simple tinted glasses could produce the above choices. But what about multi-color renderings? PK

## NASA should include Mission-Appropriate Cubesat Hitchhikers on every new Planetary Mission

By Peter Kokh

I had intended to write this editorial, but happily, NASA had “read my mind” and, no doubt, those of many others.

Planetary missions, whether orbiters or landed rovers, are expensive. So why not get more for our taxpayer bucks by requiring NASA to carry along any cubesats intended for the same destination? The extra cost will be little in comparison to the possible discoveries made by these ever more sophisticated lightweight gizmos.

[www.nasa.gov/press-release/nasa-prepares-for-first-interplanetary-cubesats-on-agency-s-next-mission-to-mars/](http://www.nasa.gov/press-release/nasa-prepares-for-first-interplanetary-cubesats-on-agency-s-next-mission-to-mars/)

Wouldn't it be nice if New Horizons had carried along a lander for both Pluto and Charon, designed to tell us about the surface chemistry of these two intriguing sister planets? Wouldn't it have been nice if the Curiosity mission could have landed a cubesat on a Martian polar ice cap to analyze the chemical and isotope mixes in the the polar ice? Wouldn't it be nice if Dawn carried along a cubesat lander with an open mission, which could be landed in one of Ceres intriguing white spots.

Why not more than one cubesat? Mission slots are hard to come by. Adding one or more cubesats aimed at complementary science at the same destination, could tell us more, much sooner. What we are learning about the solar system is phenomenal. But with a mandate from Congress, we could be learning more, and sooner. PK

## Space Settlement the Easy Way

By Al Globus, San Jose Unibersity

At ISDC 2015 in Toronto, I gave a talk entitled “Space Settlement the Easy Way,” by myself and Stephen Covey. The slides are now available at <http://space.alglobus.net/presentations/Easy.pdf> which will eventually be replaced by a paper;

The central idea is to build settlements **close to Earth, build it small, build it up incrementally**  
**The Plan:** make them small, and use tourism income to gradually build up hotel sizes until they are big enough to be settlements. This size is much smaller than previously thought because an extensive literature review finds that human rotation tolerance is much greater than believed by the space settlement community.

The talk takes advantage of the results of the two papers (see below) that suggest that orbital settlements can be hundreds of times less massive than we have thought and that equatorial (0 inclination, that's important) LEO below about 500 km is an excellent location for early space settlements. It appears that radiation shielding, 90+% of the mass of typical settlement designs, is probably unnecessary in equatorial LEO making launch from Earth very competitive with asteroidal or lunar materials. This result is supported by calculations using OLTARIS, NASA's web front end to very sophisticated space radiation codes.

**The papers (preprints):**

“Space Settlement Population Rotation Tolerance,” Al Globus and Theodore Hall

<http://space.alglobus.net/papers/RotationPaper.pdf>

“Orbital Space Settlement Radiation Shielding,” Al Globus and Joe Strout

<http://space.alglobus.net/papers/RadiationPaper.pdf>

Ad Astra!

## International Lunar Decade Declaration

At the International Space Development Conference, Toronto, Canada

By the National Space Society, May 25, 2015.

**“If God wanted man to become a spacefaring species, he would have given man a moon.”**

Krafft Ehrhke Lunar Bases and Space Activities of the 21st Century (1985)

We recommend that an International Lunar Decade (ILD) be initiated no later than on the 60th anniversary of the International Geophysical Year in 2017 with the full endorsement of ISECG nations. We urge that a campaign of lunar scientific exploration and geophysical investigation, infrastructure development, and commercial involvement be incorporated in any further formulation of ISECG's Global Exploration Roadmap by 2017. It is also recommended that those ILD projects be undertaken by non-binding voluntary collaborative efforts among

ISECG member states, public private investment partnerships, and commercial-industrial partnerships.

Those attending the NSS International Space Development Conference assembled to discuss the technical, economic and policy choices available to provide sustainable infrastructure in cislunar space and on the Moon. Our purpose was to enable further exploration of the Moon and its scientific, industrial and commercial development as a destination for permanent human settlement beyond the Earth and as a gateway for further exploration, human settlement, and economic development throughout the Solar System.

### Shared Understandings and Beliefs:

The exploration and development of space presents multiple opportunities to carry out a series of discrete, time limited and cost feasible objectives. Their realization requires a long-range view that can accommodate varying economic and political conditions among nations working collaboratively at multiple levels in an International Lunar Decade (ILD) campaign. The peaceful development **and use of space resources** should be the right of all nations, with no nation excluded. Access to space **and the use of space resources**, as recognized by the Treaty on the Peaceful Uses of Outer Space, can enable a permanent human presence on the surface of the Moon, the extension of human presence in cislunar space and beyond, and the development of an Earth-Moon economy that welcomes and includes participation from all countries.

Rapidly advancing space technologies now offer higher performance at lower cost thereby opening opportunities for many more nations, research organizations and commercial businesses to work in both cislunar space and on the lunar surface.

**We therefore recommend that spacefaring nations participating in the International Space Exploration Coordination Group (ISECG) provide leadership by launching an International Lunar Decade in 2017, (on the 60th anniversary of the International Geophysical Year) to:**

Further expand the ISECG through participation of all G-20 nations as well as those with smaller economies using affordable lunar cubesat scale spacecraft and sensors, secondary payloads, and reusable launch systems and the institutional resources of universities and commercial organizations.

- Build on the extensive scientific and engineering foundations of the Lunar Exploration Analysis Group (LEAG) Roadmap, Strategic Knowledge Gaps, and International Lunar Exploration Working Group (ILEWG) to meet scientific objectives and identify the locations of resources and sites where permanent human settlements and scientific, industrial, and commercial facilities can best be located.
- Establish an International Lunar Survey Working Group (ILSWG) to be responsible for sharing of lunar exploration data and to integrate mapping data from national lunar missions through a common geodetic registration to produce increasingly accurate and comprehensive maps of the Moon's surface within the context of the ISECG.
- All countries and commercial entities should have access to these nationally gathered data to facilitate scientific exploration, research, commercial activities, the location and utilization of lunar resources, and general economic lunar development in a rapidly expanding Earth-Moon Economic System.

The ILD organized within the framework of the ISECG would include working agreements, trial protocols, and common international standards, providing for transparent and open participation of all the nations in the exploration and economic development of the Moon. The framework recognize the property rights of both individuals, commercial and nongovernmental entities, (rights to access and use), recognize investments and financing of lunar infrastructure, and identify mechanisms for multilateral dispute resolution in the context

of the Treaty on the Peaceful Uses of Outer Space.

Specific ILD Infrastructure projects and milestones of development could include:

1. Fuel Depots in LEO and E-M Lagrange locations, and the lunar surface which extend our reach in space.
2. The development of navigation and communications infrastructures, in cislunar space and on the surface of the Moon.
3. The further development of detection and tracking space observatories, which can detect both space debris and near-Earth asteroids.
4. A permanent E-M L2 station as both a research and gateway facility and for teleoperations on and transportation to the lunar surface.
5. A permanent human base on the lunar surface,.
6. The development of affordable cubesat scale spacecraft and space lab projects, expanding educational, scientific, and commercial opportunities for a broad array of ISECG members.
7. Research, development, and commercial initiatives, including use of lunar in-situ resources leading to a high degree of self-sufficiency.
8. An International Lunar Research/Development Park Working Group should be formed with members from commercial entities and national space agencies to provide terrestrial demonstrations of common-standards, new technologies, and interoperability of systems that will subsequently operate in cislunar space and on the lunar-surface. (as well as precursor technologies for use in orbit around and on the surface of Mars).

Reference: <http://www.nasa.gov/exploration/about/isecg/>.

## Return To The Moon International Lunar Decade Workshop at ISDC 2015

Dave Dunlop, June 5, 2015

The Return to the Moon – International Lunar Decade Workshop at the 2015 ISDC in Toronto Canada was a collaborative effort of the Office of Aerospace Development Hawaii Department of Business, Economic Development and Tourism and NSS, and organized respectively by Co-Chairs Jim Crisafulli and Dave Dunlop. This first workshop is one of a number of International Conference presentations of the idea of an International Lunar Decade (ILD) planned in the aftermath of the Next Giant Leap Conference in Hawaii in November 2014, by an informal ILD- Working Group subsequent to that Conference. The proposed ILD would begin in 2017, on the 60th anniversary of the International Geophysical Year of 1957–58 when some 60 countries sponsored scientific projects to study the Earth which we all share. As we approach the 50th Anniversary of the Apollo 11 landing leading space faring countries are planning to extend lunar exploration with mission on the lunar surface and in Near Moon space as reflected in the Global Exploration Roadmap of 2013 and which we all also share in the night sky.

**The Return To The Moon International Lunar Decade Workshop addressed several questions:**

**I So why is an International Lunar Decade important?  
And what more can be achieved by such an effort?**

- An ILD is an effort to encourage all of the leading economic nations (G-20 Group nations) to have their space agencies collaborate through the International space Exploration Coordination Group (ISECG). (Only 13 of the G-20 Group members now do so). Hopefully, this will expand both the available resources and rate of activities.

- An ILD is also an effort to encourage much broader international participation from smaller national economies in the ISECG through affordable space technologies and miniaturized instrumentation and spacecraft.
- An ILD is also an opportunity to expand peaceful international partnerships which have worked well in achieving the technical and diplomatic achievements of the International Space Station. Al Anzaldúa's and Vid Beldav's presentations explained how and ILD can also accelerate the rate of progress through an extension of an integrated international exploration and economic development program using cislunar space and the lunar surface as a cost effective test-bed for the requirement of Mars exploration and settlement and other space destination beyond LEO. Vid stressed that "wealth generation is the key to sustainable human presence." Too often in the past competition between advocates of explorations of specific destinations have hindered progress. The context of ISECG provides a climate of non-binding agreements and voluntary partnerships and collaborations and an integrated framework where more can be accomplished.
- Mark Hopkins provided a view of NSS activities including its current advocacy of Space Settlement to NASA's Federal authorizing legislation.

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## II How can strategic International partnerships be included in the context of an ILD?

### CANADA (Our Host Country for the ISDC 2015)

**Tahir Merali**, ISDC Program Chair provided a view of Canadian space activities and opportunities and recent consideration of a Canadian Space Policy framework in the Emerson Report of 2012. The Canadian Space Agency (CSA) has a budget of some \$260M (Canadian). The CSA also has a Canadian Space Advisory Council. The budget is spread across a variety of government priorities including Maritime Domain awareness, Fisheries, Natural Resources and its RadarSat system. Some 70% of this budget is contracted with Canadian industry. Canada's space industry has contributed to international projects most famously with its robotic Canadarm and Dexter system on the ISS. It has allocated for example some \$30M over the 4 year for telecommunications. There is interest in lunar base participation in areas of Canadian strength such as mining and metals, robotics, and the nuclear industry. Canada has also been involved in prior planning for an International Lunar Network. It has also strongly contributed to the Resolve lunar lander drilling development. Canada's Center for Planetary Science and Exploration was the first international node of the NASA Lunar Science Institute now renamed Solar System Exploration Research Virtual Institute.

**Lauren Small**—Pennefather of the CSA indicated in a Space Policy workshop presentation that the Canadian Space industry accounted for more than 8000 skilled jobs and about \$3.33 B in economic activity of which about half were exports. Some 1300 researchers in 30 universities are funded by CSA and Canada as an associate member of the European Space Agency maintain an Office in Paris and other in Washington and Houston in coordinating its collaborative activities with NASA.

**Kieran Carroll** of Cedex presented information on a new gravimeter instrument that could provide improved understanding of the subsurface of the Moon and Mars including such targets of scientific and settlement interest as lava tubes. Nadeem Ghafoor presented information on the capabilities and interests of Canadensys in lunar surface exploration and mission development including work on the telescope for the International Lunar Observatory association. Canada is among the G-20 nations represented in the International Space Exploration Coordination Group with continued interest in the responsible use of space. Canadian Space Agency's former senior executive David Kendall is the incoming Chair of the UN Committee on the Peaceful Uses of Outer Space for the 2016-2018 term. He said space is increasingly congested, geopolitically competitive, and contested and that interesting times lie ahead in the next few years.

### CHINA

Although unable to travel to Canada, Li Ping of the Chinese Academy of Space Technology did graciously provide a presentation of China's growing space capabilities to Dr. Feng Hsu who made this presentation to the ILD workshop on his behalf. China's Chang'e III mission which successfully landed on the Moon in 2013 demonstrated autonomous guidance, and dynamic laser and microwave ranging and velocity determination. Its rover was designed for a 5 kilometer range permitted by its power supply. This mission also used 7500 Newton thrusters.



China is planning a Chang'e V lunar surface mission demonstrating autonomous sampling for a planned 2 kg sample return mission in 2017. The Chang'e IV back-up mission to Chang'e III has been repurposed to the lunar farside surface mission in 2020. This would be the first lunar mission to land on the lunar farside. The CNSA is also developing a heavy lift launcher to advance its ability to conduct more ambitious missions. It will build both an international space station by 2022 and conduct additional lunar surface scientific exploration. China has already reached out to seek international participation in its space station development program and a collaborative effort with Russia in this regard was recently announced. China is also interested in deep space mission to the Giant Gas Planets.

**China** also has financial resources which can continue to advance future capabilities and is now by some measures the largest economy in the world. Its role in deep space exploration and development will most likely continue to grow as a global economic power. An international Lunar decade can provide opportunities to further integrate Chinese capabilities into the framework of Global Exploration Roadmap campaign and those of other international space agencies.

## INDIA

NSS was privileged to have Mangesh Sannala, Counselor Space for ISRO at the Embassy of India in Washington D.C attend the ISDC to receive the NSS Space Pioneer Award for its Mangalyaan Mission now orbiting Mars. Indian has also increased its ability to undertake missions beyond LEO such as Mangalyaan (and the upcoming Chandrayaan II) by the development of a network deep space communications facilities around the globe including Brunei, Biak, Mauritius, Canberra Alcantera ships dispatched to the Pacific Ocean for tracking. High throughput satellites in the Ka and Ku band will also be introduced. The recent successful suborbital test demonstration of its GSLV Mark 3 will be followed in 2017 by the launch of a Geostationary satellite. ISRO has also pioneered going online on social media to enhance its outreach to "the common man."

A.S. Kiran Kumar who became ISRO's new Chairman in January has recently announced that the Chandrayaan-2 mission had begun a fully indigenous development effort with an orbiter, lander, and rover planned. Initial tests of a 6 wheel rover on a lunar terrain test facility have been conducted. Payloads for the orbiter, lander and rover have been selected and are in development. New technologies in navigation, guidance and control, soft landing, and sensors will be used on this lander and this mission is projected to be completed in the 2017-2018 window. His announcement also indicates ISRO also anticipates placing a solar observation satellite "Aditya" into an Earth-Sun Lagrange 1 orbit where it will not be occulted and have a continuous view of the Sun in the same 2017-2018 time frame as Chandrayaan -2. ISRO also anticipates growth through its Antrix Corporation commercial arm and small and medium size businesses for a growing demand for satellites.

India's growing economic power is also reflected in the advances of ISRO with successes of Chandrayaan I and Mangalyaan I under its belt and advances in propulsion, instrumentation and communications. India's capabilities to contribute to an ILD as a significant partner is also also a factor that can accelerate the campaign to "Open Lunar" to both more exploration and economic development but also to pioneer applications which can be applied to Earth's environmental, social, and economic challenges. ISRO also shares interest in further extension of collaborative efforts in Mars exploration.

## Space Debris

**Al Anzaldua** provided a presentation of the common threat of space debris to both existing space infrastructure and \$200B commercial space economy as well as to future ambitions in the exploration and development of the Moon and advances into deep space destinations such as Mars and the asteroids. Critical attention must be focused on new technologies and capabilities needed to clean-up existing space debris, prevent additional shrapnel from being formed, and to potentially use materials salvaged in space as a resources for further construction. Efforts to discuss current technologies and options will be the focus of a ISDC 2017 workshop and reflect NSS priorities in advocating for collaboration with other space advocacy organizations and for international action and strong US participation.

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## III How can Lunar Exploration and development requirements for power also engage the community of interest and research in Space Solar Power Satellites and Power Beaming.

**Keiran Carroll** described how laser power beaming could enhance the capabilities of lunar surface rovers and help them survive the requirement that they survive the lunar night. These facilities might

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

extend the functionality of rovers by recharging batteries quickly expended from loads expended in cryogenic operations. They might reach from PVC power generation facilities on locations with extended illumination to surrounding locations within line of site of a laser power beaming installation. He suggested that a price point for a lunar rover with a power mast might fall in the range from \$ 20–30M to \$50M.

**James Schier**, Chief Architect of the Space Communications and Navigation program at NASA HQ presented the potential of a pair of laser power beaming satellites in an elliptical orbit to provide beamed power to either rovers, mining equipment or other stationary equipment on one hemisphere of the lunar surface. This might provide an element of a “lunar surface power utility” which could be used by international customers and financed by public and private partnerships. Early cost estimates on this type of dual satellite system might be as much as \$500M. Determining the cost benefits of such technologies to the international space exploration community and within a customer–provider context are current challenges. Identifying customers may be a result of showing the cost–effectiveness of such power systems on the service life and productivity of lunar surface resources, reduced costs through common design standards and elements, and transparent methods of cost allocations to the customer base. ISSECG might provide a context for determining the lunar surface power beaming requirements. He also provided some history on the early commercial partnership in the development of the DTRSS system which was later taken over by NASA. Joe Bland and others in the NSS L5 Chapter in Sacramento have also focused on lunar power beaming analysis and presented their work in an article at [www.sacl5.org](http://www.sacl5.org).

NASA is proceeding to invest in laser communication facilities on the big island of Hawaii over the next couple of years to further support space communications abilities in cislunar space.

NSS Policy Chair Dale Skran provided an overview of the role of the International Telecommunications Union and its role in GEO space in assigning frequencies and also in allocating the limited slots for GEO communications satellites. He noted there is little in the way of enforcement mechanisms but ITU rules are followed globally to a high degree. In cislunar space its role is less clear but there is a proposed farside pristine central section centered on Daedalus Crater and extending 150 degrees East and West and comprising a radio shielded zone of the Moon reserved for radio astronomy. Other questions about the number of orbital options for “frozen and low energy trajectory orbits and their assignment may extend its role in further international regulatory efforts.

Currently new laser optical communications technologies pioneered by NASA on the recent LADEE mission are much higher frequencies than radio are not the province of ITU. Radio Frequency Classes include: S band 2 Ghz, X band 8 Ghz, Ka band 32 GHz

A NASA proposed Laser Communications Relay Demonstration (LCRD) would extend these capabilities pioneered by LADEE. Lunar HALO orbits might provide good polar orbital locations. Evolution of a “Lunar Net” might involve an international consortium agreement to a “Lunar Authority”. Commercial options might involve barter partnerships for a certain percentage of capacity.

Dale noted that other groups also connected to international use include International Engineering Task Force and the Interplanetary Network Architecture Special Interest Group.

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#### IV How Can An International Research Park Initiative advance the further Exploration and Economic Development of the Moon.

**Jim Crisafulli** talked about how an International Research Park could create a cost effective mechanism for international, commercial and massive individual participation, in lunar exploration and economic development. He also presented information about the Pacific International Space Center for Exploration Systems (PICSES) program started in 2007 as a model for further analog demonstrations of lunar surface explorations capabilities as well as in local economic development with direct tangible benefits. Partners can operate in close proximity and development workable operational relationships. Research for example on lunar ISRU regarding the use of sintering basalt can not only provide tools for construction on the lunar surface such as landing sites but on Earth as well as evidenced in road construction. This facility can provide education and training and multi–national dialogue and exchange. A variety of space agencies including NASA, CSA, ESA, and JAXA as well as GLXP teams have used these facilities for engineering and technology demonstrations. What can emerge at PISCES is a “system of systems” capability for cislunar and lunar operations operations.

**Bruce Pittman** talked about various elements of an ILRP. He discussed a current focus at the Draper Fisher Jurvetson venture capital firm on the potential for radical cost reductions for a 10 person lunar base. This project uses elements such as the Dragon 2 capsule, Falcon 9R reusable rockets, and Bigelow BA 330 inflatable habitation elements that promise perhaps an order of magnitude cost reduction from the \$150B expenditure levels for the International Space Station, perhaps down to the \$5B level. An Early system might supply 1.5 Metric tons to the lunar surface. A "Griffin" Lander design adaptation of the Dragon capsule might provide 6 MT to the Lunar Surface. These facilities have projected cost for a 60 day stay per individual which amount to \$25.6M. A lease for a facility might be \$1Billion a year. Private-public partnerships in this model have public partners which could be anchor tenants under lease agreements which provided a sustainable level of funding but also provide a return on investment on private investment. Current operational costs for the ISS run about to \$3B a year as a comparison price point. Bruce indicated that one perspective is "Think Big, Start Small, but Start".

**Dave Dunlop** discussed exploration of cislunar economic models which close the case for commercial participation and return on investment. They are a key part of current academic, commercial, and NASA interests. These economic models address the demand versus supply of various goods and services including important elements such as transportation and fuel, habitation facilities, and communications and the capital requirements involved and return on investments of each element. One focus is to look at how each activity can generate a revenue stream and how various proposed elements can reinforce each others economic justification. An important question is to determine when and how a "critical mass" of activities is reached that generates a positive economic return. Some feel that fuel production on the lunar surface and for export is the earliest and most critical element. Others feel that a mixed strategy of both deep space and lunar exploration, science, local lunar ISRU, and even tourism supported by international space agencies and commercial investors can provide a sustainable cislunar economic model. Yet others feel that yet more distant space solar power satellite requirements for massive use of lunar resources driven by global clean energy demands will prove to be the key economic driver of the cislunar economy and the basis for lunar economic development.

There is a current economic study (RASC-AL) being undertaken at USC by James Wertz with NASA funding which is looking at the feasibility of pursuing a human return to the Moon within the context of a NASA's budget's fixed purchasing power over the next twenty years which should be completed by the fall of 2015. Similarly economic studies have been done on the feasibility of pursuing a humans to Mars program within the context of a NASA budget of fixed purchasing power. Recent comments by the new head of the European Space Agency reflect interest in the scientific potential of a lunar farside base. An ILD campaign which is but the first phase of an integrated international effort to explore and develop the Moon on the way to Mars and the asteroids is also a strategy to enhance available resources and accelerate the pace of the campaign through greater international and commercial participation. James Wertz and others have also suggested that proposals projecting a 1000 people on the Moon may provide a geometric model of economic growth for the cislunar economy and a radical departure from more conservative linear growth projections of current levels of government space expenditures.

Dave Dunlop also spoke about the idea of an International Lunar Survey Working Group within the context of ISECG to provide a common geodetic framework for the international exploration activities of ISECG members. This objectives would provide for the comparison of data sets from individual lunar exploration missions within a common geodetic registration so that these data sets would have optimum scientific utility and more efficient use of resources could result. Many of these technical cartographic recommendations have been made by Dr. Brent Archival of the US GS Astrogeology Division. An International Lunar Survey Working Group could also assist the economic development of lunar resources discoveries, by provide accurate mapping of resources, and discoveries which could effect their commercial uses.

**Brad Blair** also addressed the key strategic requirements of commercial customers in creating a genuine cislunar economic market place and how commercial interests in lunar mining and manufacturing would shift both investment and operational requirements from those of a NASA monopoly to a more diversified range of providers. The was also echoed in another ISDC presentation by Ted Hewitt of Western Ontario University who said " the key challenge is getting people into the space equation."

Blair contrasted the more broad responsibilities of government funded agencies in contrast to more

narrowly focused efforts of commercial organizations to develop highly efficient business models producing a return on investment.

Similarly, **Bruce Pittman** talked about the potential of an International Lunar Lagrange Station as a Gateway for further exploration and a key piece of infrastructure advancing both exploration of the lunar surface and destinations such as Mars. Potential locations include Earth-Moon Lagrange 1 or 2 or a Low lunar orbit. A model for this project is the work done on the Nautilus Station design done by Mike Holden and others. Recent comments by NASA Administrator Bolden also reflect NASA's efforts to developed infrastructure enabling further advances in Exploration beyond LEO which compliment International Partners who are more focused on returning to the Lunar surface.

Bruce also talked about the commercial development of the International Space Station after 2024 and consideration of its evolution with commercial investors and international partners. The ISS is currently too expensive. It may well be replaced by more cost efficient commercial evolution of the ISS or new commercial stations or both.

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### **Return To The Moon – International Lunar Decade Follow-ups**

- 1 Following the 2015 ISDC ILD Workshop the NSS issued its endorsement of an International Lunar Decade with a ILD Declaration thereby lending its voice to this campaign.
- 2 NSS can continue to work with the International Lunar Decade Working Group to collaborate its conference and educational activities with those of other organizations. It will host ILD Workshop materials on its web-site. It will provide 2016 ISDC programming on key ILD initiatives in Space Debris, Lunar Solar Power Applications, and Communications Infrastructure, and Propulsion applications, and economic models of public-private investments and partnerships which close the case for further exploration and development. It will also participate in other international Conference forums such as the UN COPOUS Committee, the International Astronautical Conference in Guadalajara, and the International Lunar Exploration Working Group Conference on the Exploration and Utilization of the Moon in Istanbul.
- 3 NSS can advocate through its policy committee and through its collaborative Alliance for Space Development for US Congressional and Administration support for an International Lunar Decade within the context of collaboration in the International Space Exploration Working group.
- 4 NSS can also advocate for stronger commercial participation in the ISECG and public and private collaborations across the broad spectrum of international participants. NSS can provide another opportunity for commercial consideration of International Lunar Decade objectives through a Fall 2015 workshop in Mountain View, California.
- 5 NSS can also advocate for more affordable technology applications that will lower the barriers for participation to many small countries, academic, and commercial organizations.
- 6 NSS can also utilize its status as an NGO in the United Nations to advocate for the endorsement of an ILD by the UN Committee on the Peaceful Use of Outer Space and UN Committee on Space Research and in the Social and Economic Council as a means of advancing global scientific, technical progress, and social and economic benefits.
- 7 NSS can continue to advocate for Space Settlement to be added to the NASA's enabling legislation and for NASA's participation in an ILD toward that objective.
- 8 NSS can advocate that an ILD campaign include the Science Priorities laid out in the LEAG Roadmap, Strategic Knowledge Gaps, and NRC Report on "The Scientific Context of the Exploration of the Moon and in the Solar System Exploration Research Institute expanding network of International Nodes.
- 9 NSS can advocate for an ILRP program which advocates for strong US participation in this program of infrastructure development.
10. NSS can advocate for an International Lunar Survey Working Group which can both share exploration campaign results, provide a common geodetic registration for mapping lunar data sets, and accelerate the economic use and development of discovered lunar resources. **DD**

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## Expanding Economic Models for Returning to the Moon and the International Lunar Decade

David Dunlop June 15, 2015

### Is it cost feasible to return to the Moon?

Apollo Astronaut and former US Senator Harrison (Jack) Schmidt's study of the costs of the Apollo program indicated that the Apollo Astronauts time on the lunar surface cost approximately a million dollars a minute. The Space Race to the Moon was a bargain compared to a global nuclear war but still so expensive that we haven't been back going on 50 years. The space advocacy community seemingly oblivious to such costs has nevertheless called for greater adventures and explorations and a manned program that has stretched from the Shuttle through to the International Space Station and aspires now to go to Mars. Many conservative skeptics of all this question the economic utility of even these expenditures. Those space advocates untamed by economic limitations want to go to Mars now! Many are essentially heedless of the costs, or the substantial risks to human life involved. Apollo generation advocates do not want to see a repeat of a Flag and Footprints strategy where "been there done that" attitudes then shut down decades of effort in an unsustainable dead-end campaign to the Red planet. Mars offers no hope of a short economic return but some hope for a very few if humanity is extinguished on the Earth by natural or self induced causes.

Many in the space advocacy community like me were imprinted like ducks by the Apollo campaign. The issue of a permanent human return to the Moon has like dandelions surfaced previously under both Bush administrations. The ISS coalition of nations seems largely lined up in support of this enterprise but the Obama administration sidelined this objective when the economic collapse forced a re-trenchment of NASA's ambitions and Obama opted for a Mars legacy.

Mars, a distant objective perhaps 20 years or more beyond the Obama administration was deemed the key strategic goal as a time when the US had been actively engaging its ISS partners for a return to the Moon. No economic case for space solar power satellites had been established either at that point, another case in point of the economic irrationality of space advocates in the opinion of many economic conservatives.

### Climate Change for a Lunar Return

Now we have reached a clear turning point where the economic feasibility of returning to the Moon is no longer a giggle factor. Reusable rockets promise a huge reduction in launch costs. Miniaturized spacecraft and science instruments and affordable secondary launches make science in cislunar space more affordable. The rise of a class of billionaire entrepreneurs interested in space investments has also changed the climate. And NASA has continued to deliver stunning surprises about the potential of the Moon's economic development with the potential of recovering rocket fuel from ice deposits. An economic case for space solar power has also recently emerged since 2012 which holds the promise of clean energy for a world desperate for clean energy. A global public has been swept into the internet age with ubiquitous smart phones and mobile platforms. All of these developments of the last ten to 15 years have set the stage for reconsideration of a permanent and cost feasible human return to the Moon.

But this is not just my assertion. A litany of others have recently come to similar conclusions addressing some basic questions:

### A Could a Lunar Return be done affordably with a credible technological scenario?

- 1 Jeff Greason ISDC Speech: **Yes**, "The reason to go to the Moon is to make gas" – 2011 Huntsville, Alabama speech to the ISDC
- 2 John Strickland (Lunar Ferry Architecture and Reusable Rockets) **Yes**, a similar architecture of reusable launchers and elements of orbital infrastructure and in-space vehicles can make both the settlement of the Moon and Mars feasible.
- 3 Kathy Laurini et.al., Reference architecture for Human Lunar Exploration ( 2010 IAC-10.A5.2.9 paper): **Yes** (Post Constellation Design Reference Model)

### B Is it cost feasible to return to the Moon on NASA's Budget?

4 Paul Spudis Tony Lavoie ( NASA) & LPI 2011 (Yes with NASA's costing methodology and NASA's budget used in this study)

5 Gordon Woodcock ( Retired Boeing Engineer) 2011 Yes

6 James Wertz (USC- NASA funded RASC-AL) 2015 Expected to confirm a feasible return scenario under a NASA budget of stable purchasing power over the next twenty years. A not dissimilar conclusion was recently also reached about the feasibility of going to Mars on a NASA's budget of flat purchasing power.

(Citation)

7 Ad Astra's Winter 2015 issue made reference to NASA Lunar studies and the author was a former NASA budget analyst (find citation)

8 James Wertz et al. A 1,000 person Lunar base is premised on a Geometric Growth .Model) A study has been proposed but not funded

### C Is it cost feasible to return to the Moon without NASA in the lead?

#### Options:

**I No.** A single national effort at present does not seem politically feasible and therefore cost feasible under the current administration and NASA system. (This is a question of time for other nations such as China if they would choose that policy option)

This is a question of time for a coalition of other nations including China, the EU, Russian, and others. **The longer NASA is not in the lead, the more the question "Is NASA relevant?" becomes the question.**

**II Yes Option A:** at present, by a coalition of nations supporting a lunar base with commercial partners with NASA "leading from behind", with commercial participation in public private partnerships in enabling infrastructure. The Off World Consortium model might fit this option.

**II Yes Option B:** A multi-national consortium might provide another alternative structure for a lunar return with Russian and Chinese cooperation on a space station perhaps also with European participation building towards a lunar base project. Political and economy tensions might therefore produce two viable and parallel lunar programs.

**III Yes Option C:** Mega-corporations such as Google, or Amazon, or Space x or a Chinese provider of reusable launch systems and global internet systems ambitions might have sufficient capital and market income to create GEO platform structures and associated infrastructure which require and draw down lunar developed resources.

The Off-World Consortium model may simply be the first attempt to implement this model of lunar economic development. Future projections

A Google LXP Sponsored London Economics provided a study which projected \$ 1.9 B in market value in the 10 years following the GLXP (GLXP Market Study 2014 Media Summary). Continued robust growth does it seem likely based on global demands for satellite based services and their technical feasibility

B Demands for clean solar power and associated clean water production provide a longer term scenario for economic growth squarely dependent on growth in the cislunar space economy.

Does an International Lunar Decade Campaign provide added value to these growth scenarios?

Yes, but much less probably without NASA involvement in the context of ISECG collaborations

Nevertheless an ILD is possible with Competitive International Model (The strategic basis for an ILD campaign is to reinforce "the other 50%" of space faring nations.)

1 G-20 Group inclusive (Strategy assumes Chinese participation in a commercial framework with national assets) LD Strategy engages 8 G-20 countries not currently participants.

2 G-20 Group + Countries inclusive (ILD- ILGY Campaign) (Affordable missions and instrumentation Lunar Cube paradigm)

3 Commercial investment in public private partnerships - NASA Model II NASA's Existing Strategy: Seems to be swinging back to Lunar support) US (NASA + commercial sector provides infrastructure for a lunar return) President Obama has pursued a "Flexible Path Architecture" that was recommended by the last Augustine Commission.

## What does an International Lunar Decade Program Look Like?

### Elements in ILD list:

- E-M Lagrange Station Yes No
- **ILRP: Internatiion Lunar Research Park** (Commercial partnership potential) x with national anchor tenants
- (Bigelow Lease-back Model?)
- (International Research Goals associated and justifying International Leases)
- 1 Radiation counter measures & design
- 2 Long term life support systems
- 3 Tele-robotic support to lunar surface robotic sorties (Lunar radio telescope deployment)
- 4 Tele-robotic support to ILRP robotic village to human return precursor
- 5 Tele-robotic support for operationally useful lunar frozen volatiles production  
(Commercial investors with national customers)
- 6 Fuel Depot (Storage & Transfer) x Commercial facilities with national customers and private customers
- 7 Deep Space Curation Facility x
- 8 Planetary Protection Observatory
- 9 Cislunar Internet
  - 1 Laser communications system x (NASA funded infrastructure)
  - 2 TDRS system still plays a role x (NASA funded infrastructure)
  - 3 Coordinated servers on projected International Lunar Orbiter Missions  
(Commercial catalyst option?) x

### Cislunar navigation system demonstration

- 1 Atomic clock (NASA STMD initiative flight demo in 2018)
- 2 Pulsar detection navigation systems

### IV Fuel Depot in LEO x

- (commercial investors with national customers & private customers)
- (Off World consortium proposed launch 2015)

### V Low Cost Lunar Base(s)? X (potential parallel duplicative efforts)

#### Non-NASA developed: A ILRP and Commercial Option:

- 1 Bigelow Aerospace (Inflatable modules)
- 2 Other Private US & International & Commercial participants (National Anchor tenants model):
- 3 ESA (Europe) tennant ?
- 4 Roscosmos ?
- 5 JAXA (Japan) tennant ?
- 6 ISRO (India) ??
- 7 KARI (Korea) tennant ?
- 8 NASA (USA) tennant ?
- 9 Mexico ?
- 10 Brazil ?
- 11 Frozen Volatiles Mining (Commercial Open Access)
- 12 Fuel Production, Storage, and Transport Infrastructure Commercial
- 13 Habitation Facilites (Commercial)
- 14 CSNA (China) ?

### VI International Lunar Base (duplicative) ?

- National Consortium model (Replays ISS model with different actors such as Russia-ESA-China)

### VII Space Debris Clean-up Remediation

- (Nascent development with NASA STMD)
- (Commercial options needed to close business case for development with strong Russian incentives)

### VIII International Lunar Survey Working Group x

(Collaborative sharing; mapping of lunar exploration data and data supporting economic utilization

**IX Science Mission Campaign** Coordinated with x ISECG ( IUGG and Int Science Council endorsement with ILEWG and LEAG advisory groups and SSERVI working closely together. International Lunar Decade encourages many smaller country participation

X Options for smaller country engagement with affordable Lunar Cube scale spacecraft and instrument packages and affordable national and secondary launch opportunities.

XI A multi-national cislunar market place with many providers as well as customers emerges and establishes a Moon 3.0 economy.

### Current impending prospects

I Proprietary Capital Driven Model Shackleton Energy (Jim Keravala )

2 Organizing Off World Consortium with International Investors is launching in 2015 in Dubai.

3 2015 is a year where we will see if the support of Public Private Partnerships reaches a level where the Case for Human Economic Development of the Moon closes with Major International & US Investors.

II Charles Miller makes a case for a specific Mars fuel supply case

III "Traditional" Potential of commercially viable and operationally Mining useful frozen volatile deposits have not been approach-confirmed by consensus assays of the lunar surface including ground truth missions. This is the cliff hanger issue for buying down the risk in lunar volatiles production. There is no scientific consensus view of the range of operationally useful lunar ice deposits without additional missions.

The White House and NASA has stepped away from funding the Resolve Mission drilling rig which might provide such ground truth leaving this task to either foreign partners or the private sector. NASA is flying two small Lunar Cube satellites in 2018 to further determine and characterize ice deposits.

Dr. Peter Schubert production system makes O<sub>2</sub> plus silicon, engineering metals + slag. These are many products that have Return On Investment potential.(This system is patented with huge potential but not demonstrated as yet in space or with adequate financially supported research).

His feedstock is not unproven ice deposits in difficult cold and dark terrain but the ubiquitous lunar regolith, processable by his Dust Roaster and Element Separator technology. His silicon sponge batteries with twenty times the energy storage capacity of Tesla's car battery could be produced on the lunar surface and store the electrical energy during the lunar day needed to operate during the lunar night.

Current Conclusion of Economic Feasibility of Return to Moon: Yes as a privately financed venture but with national space agency as primary customers and anchors tenants with some nascent commercial enterprises such as

1 Space Tourism

2 Fuel production on the Moon's surface,

3 Fuel storage and transfer infrastructure on the Moon's surface

4 Element separator technology opens the lunar frontier and those for asteroidal bodies as well. This would also work in the near vacuum conditions at the top of Olympus Monos on Mars.

### Longer Term Competitive Context:

The discussion of cislunar infrastructure development maps very parallel to that of the requirement of the Commercial Satellite Industry in its expansion in GEO and also out to the distance of the Moon orbit. Yet almost no mention of this is made in the ISECG roadmap documents where lip service is given to commercial development options but no details. ##



## Powering a Moon Base through the Lunar Night

The Sacramento L5 Society et al – April 23, 2015

What's the most practical way to sustain a permanent Moon base through the approximately 355 hour lunar night? In 2009, a NASA concept study attempted to answer that question, according to a recently discovered slideshow<sup>1</sup>. And in March of 2014, the Sacramento L5 Society (SL5S), a California chapter of the National Space Society, undertook the task of answering the same question, eventually resulting in a detailed analysis of 20 different potential energy delivery systems. From examination of the 2009 NASA study fragments, it seems likely that the SL5S analysis has uncovered several relevant concepts that were not considered by the NASA concept study, specifically the use of aggressive laser collimating, solar pumped lasers, orbiting energy storage, beam deflecting systems, multiple linked solar converters at the lunar poles, and solar sails for station keeping.

This article is a summary of the findings of the SL5S analysis to date. The detailed analysis itself and its accompanying spreadsheet, including a full description of the 20 systems the SL5S has studied to date, can be found on the SL5S website<sup>2</sup>.

### Lift Capacity (LC)

Because it takes less force to put a given mass into LEO than into lunar orbit, and less force to put a mass into lunar orbit than onto the lunar surface, it is useful to use a given LC to determine relative masses of different systems in different locations. In the SL5S analysis, the LC is defined in SpaceX Falcon Heavy (FH) units. One FH has a liftoff mass of 1,462,836 kg<sup>3</sup>. It is assumed that the LC of one FH can put 53,000 kg into Low Earth Orbit (LEO), 17,216 kg into either a lunar or L1 orbit, and 5,739 kg onto the lunar surface.

### Electric Propulsion system (EP)

Mass doesn't necessarily have to be lifted directly from Earth to its final destination. Called FAST (Fast Access Spacecraft Testbed) in the 2009 NASA study, use of an EP reduces the LC of any given system. For the SL5S calculations, it is assumed that the propellant and EP drive used to move a mass from LEO to either LO or L1 will equal 30% of the transported mass. Since moving a mass that distance with a standard rocket approach will typically take about twice the transported mass in fuel, the potential savings are clear.

An EP system can also be used for "orbital station keeping," which can be broadly defined as maintaining an object in space in a preferred position or orbit. The 2009 NASA study included mass calculations for station keeping which have been used in the full SL5S analysis.

### Energy storage systems and an Emergency Backup power System (EBS)

The SL5S analysis examined energy storage by flywheel, electric battery, chemical, and thermal battery systems. It was concluded that Lithium-Sulfur (Li-S) batteries presently appeared to have the best specific energy (0.5 kWh/kg)<sup>4</sup>, but that other systems would benefit greatly from In Situ Resource Generation (ISRU) and would become competitive fairly rapidly once manufacturing on the lunar surface began. A specific energy of 0.5 kWh/kg has been used in the SL5S analysis as the basis for energy storage mass calculations for all systems.

Clearly, systems that rely more on energy storage will be more positively affected by any future improvement in energy storage technology. However, all systems will be positively affected to some degree, since all systems would need some minimum amount of backup power in case of emergency. In the event of a total Moon base energy system failure, such an EBS would need to be adequate to permit evacuation of the Moon base personnel to a safe habitat, probably Earth. Also, sufficient backup energy would need to be available to effect repairs, if at all possible. In this analysis, a prudent backup quantity is assumed to be 120 kWh for a (nighttime) 15 kW continuous Moon base energy system. Using Li-S, the mass of the EBS would equal about 240 kg on the lunar surface.

### Laser collimating

Aggressive collimation of the laser beam with a Fresnel optical lens could be used to dramatically reduce the diameter of a laser beam over a long distance since, for a given light wavelength and distance to target, spot diameter is inversely proportional to aperture diameter.<sup>5</sup> Per one source, "If we collimate the output from [a] source using a lens with focal length  $f$ , then the result will be a beam with a radius  $y_2 = \theta_1 f$  and divergence angle  $\theta_2 = y_1 / f$ . Note that, no matter what lens is used, the beam radius and

beam divergence have a reciprocal relation. For example, to improve the collimation by a factor of two, you need to increase the beam diameter by a factor of two.<sup>6</sup>

Accordingly, it is highly recommended that aggressive collimation be explored as a means of decreasing the divergence angle of a laser beam. Aggressive collimation may be especially practical in a weightless, weather-less environment. Because objects in space are weightless, and because space has no atmosphere, a space-based Fresnel collimating lens might only be a few mils thick. Also, it should be easier to make a high precision Fresnel lens than a high precision parabolic mirror, since it's only the thickness of the film, as a function of distance from the center, that needs to be precise to a fraction of a wavelength. Further, the film can likely warp or twist to some degree without affecting its beam-forming ability. Finally, a Fresnel lens has a higher light transfer efficiency than a mirror. In this analysis, the mass of a Fresnel lens laser collimator, including the mounting framework, is assumed to be 0.25 kg/m<sup>2</sup>, with most of that mass assumed to be in the mounting framework.

### **Solar Pumped (SP) Laser System (LS)**

The LS system analyzed in the 2009 NASA study was a PV-powered LS. Another type of LS is possible using SP lasers<sup>7</sup>. In an SP LS, the solar insolation is concentrated directly on the laser, bypassing the electrical conversion system. Efficiencies for the SP LS and the PV LS are expected to eventually be about the same, but the SP LS appears to have a higher specific power even at present efficiencies.

### **Orbiting Energy Storage system (OES)**

A satellite that is not in sun synchronous Lunar Orbit (LO) will move continually into the Moon's shadow. Adding an OES system permits an orbiting LS to continue beaming energy even when this occurs. This permits a completely different approach to using an orbiting LS to power a Moon base than was considered in the 2009 NASA study, where the Moon base only received beamed energy when the LS was both in line of sight with the base and in full sunlight.

### **Deflecting satellite System (DS)**

Use of DS satellites can in certain circumstances permit uninterrupted LS beaming, thus obviating the need for energy storage either in orbit or on the lunar surface. In one proposed system, an LS is orbited in a sun synchronous polar orbit such that it continually sees solar insolation throughout the year. Two, three, or more laser-deflecting satellites are placed in the same polar orbit and all satellites are spaced an equal distance apart. The satellites are able to deflect the laser beam either to another satellite or directly to a Moon base at the one of Moon's poles, thus continually powering the Moon base and obviating the need for energy storage. Adding a "constellation" of orbiting LS satellites with different orbits would make it possible to continually direct a laser beam to any point on the lunar surface.

A DS can also find use in other ways. Orbiting a DS constellation around the Earth would permit an LS, mounted either in LEO or even on the Earth's surface, to continually transmit laser energy to the Moon, including continually transmitting laser energy to a second DS constellation orbiting the Moon. Also, it is possible to use a series of non-orbiting DS modules directly on the lunar surface to transfer beamed energy to other locations. Finally, it is possible to mount laser systems at the lunar poles and beam solar-powered laser energy to orbiting DS constellations, distributing lunar pole-generated laser energy to Moon bases anywhere on the Moon.

### **Lunar Polar Multi-array System (LPMS)**

The LPMS assumes that a 15 kW continuous polar Moon base can be operated with three separate PV arrays situated on high lunar mountain peaks, or so-called "peaks of eternal light,"<sup>8</sup> each connected directly to the base via multi-kilometer long electric cables. Periods of darkness as long as 36 hours are still likely<sup>9</sup>, requiring an estimated additional energy storage capacity of 540 kWh. Peak power output capacity of the three PV arrays would thus occasionally equal 45 kW.

As an alternative to energy transfer by electric cable, it may be possible to deflect and transfer solar beams directly to a Moon base from multiple distant (polar) sites. The transfer would be accomplished with a series of surface-mounted DS modules, each module composed of an arrangement of lenses and mirrors. Estimates of the mass and efficiency of such solar beam deflection systems are currently in process.

### **Solar Sail Propulsion system (SSP) and the Gravity Winch**

In certain circumstances, a solar sail arrangement can be used to enhance or even replace an EP system. An SSP is advantaged over an EP because of its ability to modify a spacecraft's position without using fuel. A related idea is the use of reels to pull in or let out either solar sails or "gravity anchors"

relative to a space-based LS platform. This constitutes what might be called the concept of a “gravity winch”. A gravity winch is basically a reeled tether that’s dropped down a gravity well from a neutral gravity point such as L1. In the case of an L1LS, a tether can be dropped down both the Moon’s gravity well and Earth’s. Shifting the gravity anchors from one side to the other allows the L1LS to “balance” between the two gravity wells, similar to the way a pole helps a tightrope walker balance. In effect, it removes the “z” vector (along the Earth–Moon axis) from consideration, allowing station-keeping to concentrate on the “x” and “y” vectors.

Figures 1–3 illustrate a possible space-based L1LS that uses a solar sail and a gravity winch for station-keeping. Figures 1 and 3 show the position of the solar sails and the rotating reflecting mirrors when the Moon is directly between the Sun and the Earth. Figure 2 shows the position of the solar sails and the rotating reflecting mirrors when the Earth is directly between the Sun and the Moon. Figure 3 is a close-up showing the main framework, the main boom, the system of rotating and non-rotating reflecting mirrors, two arrays of collimated solar-pumped lasers, and the tether winches.

### The 2009 NASA concept study

The preferred system recommended in the 2009 NASA study was a PV solar array-powered Cryogenic storage Regenerating Fuel Cell system (CRFC). NASA calculated that a 5 kW continuous delivery CRFC system would store 2,000 kW–hr with a system energy density of 1.15 kWh/kg. The study’s alternate preferred system was a Fixed Orbit Laser System (FOLS) with a 16.1 hour orbit period that required a surface receiver installation with 525 kW–hr of energy storage. The laser was powered and fired (a) when it was in direct sunlight, and (b) whenever it was in direct line of sight with the Moon base.

The 2009 NASA study’s FOLS system analysis presumed an energy storage architecture that was capable of only 200 W–hr/kg. If the NASA study had used the proposed 1.15 kWh/kg CRFC to store the energy for the proposed FOLS, then the total estimated FOLS energy storage system mass would have been reduced by 83%, making a comparison between the two systems far more competitive. A probable reason for not including this consideration was that NASA was pitting the two technologies against one another to determine which development program would be funded.

### Findings

**Table 1**, entitled “Moon energy systems lift capacity in Falcon Heavy units and dollar equivalents,” collates the results of our analysis. The CRFC and FOLS systems are included for reference purposes only. It is presumed that any advances in battery technology will be applied across the board to all systems. To aid in such, a comparable system to the CRFC system but using Li-S energy storage is included as the Lunar Non-polar Surface Mounted System (LNSMS). Also, a comparable system to the FOLS system but using Li-S energy storage and aggressive laser collimating is included as the Lunar Orbiting PV-powered Laser System (LOPVL).

In Table 1, the systems are shown ranked from low cost to high cost by the column “Tot FH \$ without EP”. It is assumed that, for an initial Moon base, electronic propulsion will not be used to deliver the payloads to their ultimate destinations. FH dollars are calculated based on \$1,200/kg in accordance with the statement by SpaceX Chairman Elon Musk that “Ultimately, I believe \$500 per pound or less is very achievable”<sup>10</sup>. It’s important to note that FH dollars do not include any costs associated with developing the various systems shown in the table.

### Conclusions

The findings of the SL5S analysis are very much first order approximations. In addition, the analysis is still a work in progress. However, in light of the dramatic nature of those findings, it is felt that the systems in question merit a far more in-depth analysis than the SL5S is capable of delivering. It is hoped that this article will inspire the undertaking of such an in-depth analysis by NASA or some other interested party, to the benefit of all who dream of mankind moving outward into the universe.

### History of this analysis

In early 2014, two college students, Akhil Raj Kumar Kalapala and Krishna Bhavana Sivaraju of Rajiv Gandhi University, India, proposed beaming space-based solar energy to the Earth by way of a laser beam located in geosynchronous orbit<sup>11</sup>. On March 14, 2014, an informal “brown bag” Moon Base Working Group (MBWG) was begun at NASA/Ames at Moffett Federal Airfield in California “to develop a cost-effective plan for establishing and operating the NASA Moon Base that would be within 10% of the total NASA budget.” In March of 2014, Joseph Bland of the Sacramento L5 Society (SL5S), one of the mentors for Akhil and Krishna, suggested to Michael Abramson, a member of both the SL5S and of the

NASA/Ames MBWG, that the group examine the possibility of powering a Moon base through the lunar night with a laser either at L1 or in lunar orbit. It was later discovered that use of a LS at L1 had been proposed by others, including Charles Radley, president of the Oregon L5 Society<sup>12</sup>.

**Table 1**

Systems	Comment	Tot FH with EP	Tot FH without EP	Tot FH \$ with EP	Tot FH \$ without EP
ELEOLS	Beamed energy from Earth to a DS constellation in LEO	0.11	0.18	\$6,994,393.08	\$11,648,264.06
LOPMLS (SP)	LO Polar Multiple satellite LS - SP-powered	0.08	0.19	\$5,148,061.71	\$11,880,142.41
EGEOLS	Beamed energy from Earth to DS at GEO	0.09	0.20	\$5,644,184.77	\$12,421,191.89
L1LS (SP)	L1 based LS - SP-powered	0.09	0.20	\$5,509,163.93	\$12,713,455.23
LEOLS (SP)	Low Earth Orbit LS - SP-powered	0.13	0.20	\$8,489,042.29	\$12,797,994.22
LEOLS (PV)	Low Earth Orbit LS - PV-powered	0.14	0.21	\$9,101,346.06	\$13,268,997.12
LOPMLS (PV)	LO Polar Multiple satellite LS - PV-powered	0.09	0.21	\$5,760,365.48	\$13,293,151.11
LOPCLS (SP)	LO Polar Constellation satellite LS - SP-powered	0.09	0.21	\$5,901,666.35	\$13,619,230.04
L1LS (PV)	L1 based LS - PV-powered	0.10	0.23	\$6,388,369.35	\$14,742,390.81
LOPCLS (PV)	LO Polar Constellation satellite LS - PV-powered	0.10	0.24	\$6,513,970.12	\$15,032,238.75
L1LS (PV)	L1 based LS - PV-powered	0.11	0.25	\$6,953,572.83	\$16,046,706.53
LOPPVLS (PV)	LO Polar single satellite LS - PV powered	0.11	0.26	\$7,032,073.32	\$16,227,861.50
LOEPVLS (PV)	LO Equator single satellite LS - PV powered	0.12	0.29	\$7,912,848.74	\$18,260,420.17
L4LS (SP)	L4 or L5 based LS - SP-powered	0.46	0.46	\$29,541,301.96	\$28,992,040.12
L4LS (PV)	L4 or L5 based LS - PV-powered	0.49	0.48	\$31,378,213.28	\$30,405,048.82
LPSMS (PV)	Lunar Polar Surface-Mounted System - PV-powered	0.27	0.63	\$17,427,107.34	\$40,216,401.57
LOSPLS (SP)	LO SP-powered LS	0.36	0.82	\$22,702,339.84	\$52,390,015.01
LOPVLS (PV)	LO PV-powered LS	0.37	0.85	\$23,455,944.48	\$54,129,102.65
CRFC*	Cryogenic storage Regenerating Fuel Cell system - *Applicable to all systems requiring energy storage if practical	0.39	0.89	\$24,515,701.01	\$56,574,694.63
FOLS	Fixed Orbit Laser System - PV-powered - 2009 NASA concept study	0.96	2.22	\$61,187,986.90	\$141,203,046.68
LNSMS (PV)	Lunar Non-polar Surface Mounted System - PV-powered	0.99	2.28	\$62,808,236.88	\$144,942,085.10



Figure 1

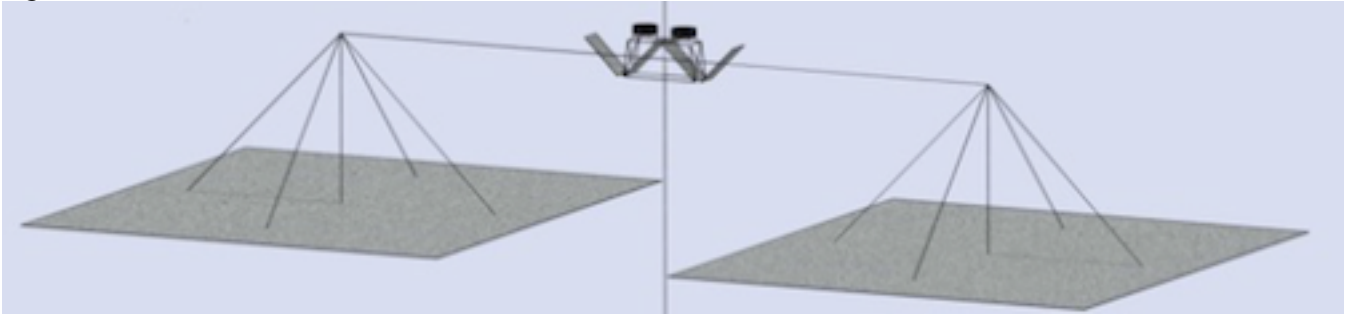


Figure 2

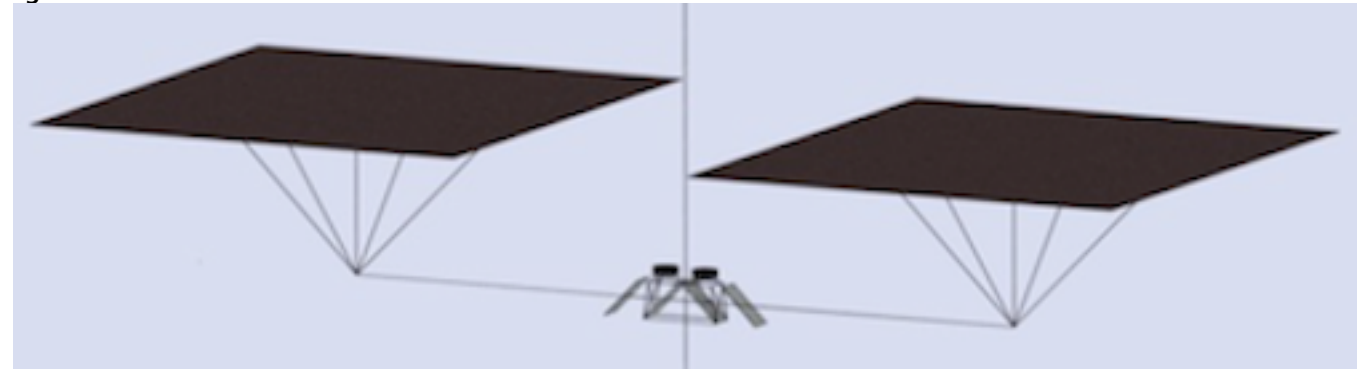
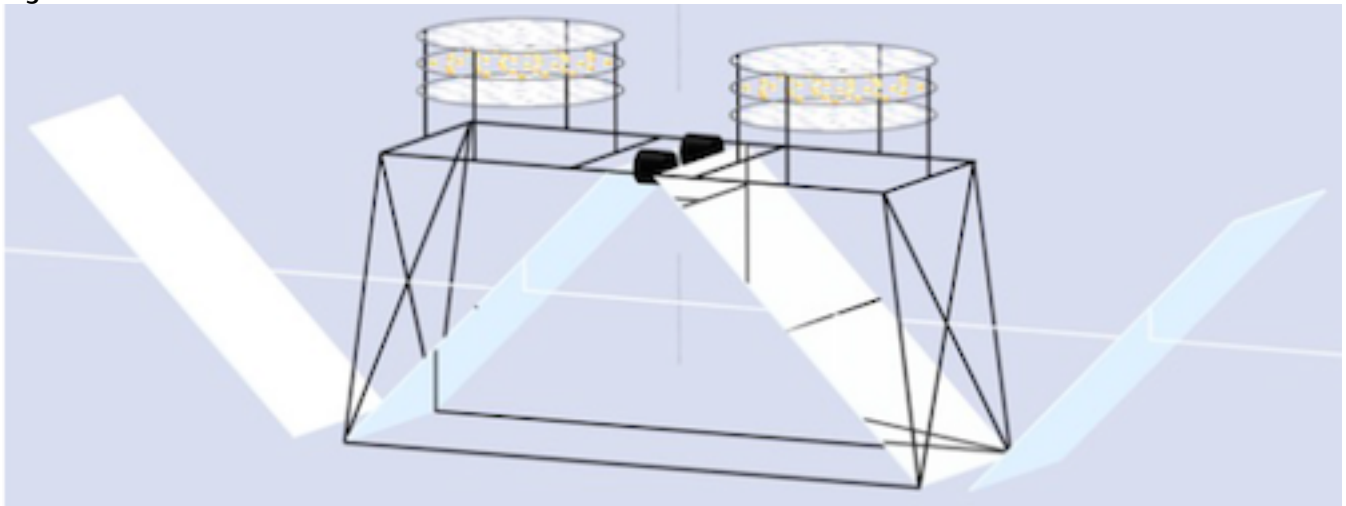


Figure 3



1 [http://www.nasa.gov/pdf/315858main\\_Cheng-yi\\_Lu.pdf](http://www.nasa.gov/pdf/315858main_Cheng-yi_Lu.pdf)

2 [sacl5.org](http://sacl5.org)

3 [http://en.wikipedia.org/wiki/Falcon\\_Heavy](http://en.wikipedia.org/wiki/Falcon_Heavy)

4 <http://www.gizmag.com/lithium-sulfur-battery-energy-density/29907/>

5 SL5S member Roger Arnold

6 <http://www.newport.com/Focusing-and-Collimating/141191/1033/content.aspx>

7 [http://www.asteroidinitiatives.com/Papers/files/Solar-pumped-laser-white\\_paper.pdf](http://www.asteroidinitiatives.com/Papers/files/Solar-pumped-laser-white_paper.pdf)

8 [http://en.wikipedia.org/wiki/Peak\\_of\\_eternal\\_light](http://en.wikipedia.org/wiki/Peak_of_eternal_light)

9 <http://ntrs.nasa.gov/search.jsp?R=20120010094>

10 [http://en.wikipedia.org/wiki/Falcon\\_Heavy](http://en.wikipedia.org/wiki/Falcon_Heavy)

11 <http://spacejournal.ohio.edu/issue18/helioastra.html>

12 <http://lunarelevator.com/wp-content/uploads/2014/07/NASA-Lunar-CATALYST-Final.pdf>

**Editor:** Great work! Kudos to the Sacramento L5 team!

## The Moon or Mars: Flawed Debate, False Choice

By Madhu Thangavelu

<https://pressroom.usc.edu/madhu-thangavelu/>

The Moon or Mars debate continues despite every single report or recommendation from NASA, NRC or other independent study that point to the Moon as the next logical destination for human space exploration and settlement. Once we hone the technologies to live there, “this time to stay” as the Bush administration of yore put it, we would have all the tools to live on Mars, return resources from the asteroids, homestead on Ceres or even the much prettier outer gems in our solar system like the satellites of Jupiter or Saturn, where the vistas are far more spectacular and seasonal changes more dynamic than anything that Mars or Venus can offer.

The physical facts are right above us in the skies every night, right in front of our eyes, for those doubting Thomases. The Moon is our closest celestial neighbor, a lifeless and barren continent, that orbits the Earth, just a quarter million miles away whereas planet Mars is at least five hundred times more distant, depending on orbital alignments. Literally and symbolically the Moon is a highly visible orb in our skies, compared to a peach pale dot that planet Mars is, that many who advocate cannot even locate in the empyrean.

Current technology allows us to ply rocketships in cislunar space, i.e., between the Earth and the Moon, every day while there are only very limited windows of opportunity to depart Earth to go to Mars. Rocketships to the Moon are much smaller, ten to hundred times smaller, depending on what and how many crew you wish to carry on expeditions, especially propellant, food and potable water. And mission control can keep check almost instantaneously round the clock. We can even mount rescue or emergency missions in short order, should the need arise. We cannot do this for Mars missions using current technology. The communications time lag during most of the Mars expedition is such that mission control on Earth can do nothing to help in an emergency. Even prayers can take 30 minutes or more to reach a transiting Mars crew in trouble. We can resupply Moon missions every day, if we so wish, but Mars crew are stuck with what they have onboard for the length of their journey that may last five to six months. And imagine this: floating around in weightlessness for five or six months, and then all of a sudden, crew are subject to gravity forces upon landing on the Martian surface. Even crew returning from much shorter trips to the ISS need a lot of time to regain their muscle and bone strength once back on Earth.

The saving grace about Mars is that they will experience less than half their body weight on Earth and be able to adjust to a similar diurnal rhythm of approximately 12 hours of night and day. But what use is that when you need to be fully suited and unable to breathe the almost pure CO<sub>2</sub> atmosphere, and that too, at such a low pressure as to be of no use at all, not to mention the dust storms that can mask the sun for months at a time. Solar photovoltaic arrays that power the ISS today have been the mainstay for space systems and satellites since the dawn of the space age, but this technology will not suffice for Mars habitats because of dust storms in the thin atmosphere block out sunlight, and nuclear power and propulsion systems are decades away from certification by NASA. We could use mature and reliable space qualified photovoltaics in those polar regions of the Moon almost perpetually while we learn to deploy, operate and service nuclear reactors that could be commissioned later on as these systems are proven on the lunar surface, on Mars and other destinations further out in the solar system, where the sunlight gets progressively dimmer and solar power becomes untenable.

The emerging robotic construction technology has huge ramifications for planetary infrastructure establishment, and that is especially true for the Moon. It is now possible to erect or build entire habitable structures, certify and commission them before humans arrive at the destination to occupy them.

Lunar settlements and associated infrastructure elements like landing pads, roads, storage hangars and even component manufacturing factories and their supply chains may all be set up and serviced from Earth. Robotics technologies have advanced so far that robots landed on the Moon, may be controlled from Earth, using advanced telerobotic systems and technologies that are already playing a vital role here on Earth. It is much more challenging to build infrastructure on Mars this way, let alone steer a rover that is hundreds of million miles away because of time delay associated with command and control signals.

Why is NASA's Mars plans always thirty years away? This is a question often asked in policy meetings but never even brought up in any technical gatherings. The reason is simple. We do not have the technologies currently to keep people alive and well for the long duration missions through the deadly radiation environment that pervades interplanetary space, especially in our neighborhood close to the sun, where life evolved and we live happily, thanks to the protection offered by Earth's magnetic field and the thick blanket that is the Earth's atmosphere.

Even the International Space Station is protected by the Earth's magnetic field, blanketed by the Van Allen belts where the often lethal solar storms are moderated and much of the fury of our sun is quenched. Neither Mars nor our Moon have such a protective field which is responsible for planet Earth holding an atmosphere, and that is very troubling for permanent extraterrestrial settlements. Artist impressions of people flying around in low gravity with magnificent vistas in the background may need serious revision. Space architects think that all extraterrestrial settlements may be deep underground with few observation towers and habitable facilities on the lunar or Martian surface which may be human tended only for very short periods in order to avoid excessive exposure and consequent radiation damage to human tissue.

Recently discovered lunar and martian lava tubes are now considered prime candidate locations for establishing the first permanent extraterrestrial settlements because they offer natural protection from the sun's wrath, the constant micrometeoritic bombardment as well as moderate thermal stability that is much harder to ameliorate if habitat structures are put up on the extraterrestrial surface that present extreme diurnal variations, up to 300 degrees Celsius on the Moon and nearly 100 degrees on Mars.

Now compounding this natural phenomenon is yet another. It is called galactic cosmic radiation, abbreviated as GCR. Mostly composed of iron ions, some of these sub atomic particles pack energies comparable to baseball fast pitches, and are constantly zooming through interplanetary space. Thought to originate at the death knell of stars or supernovae, their energies are several orders of magnitude more than what we can generate here on Earth, even in the most advanced accelerators ever built. These particles are so powerful that they go right through spacecraft and human tissue alike, but they also generate secondary particles upon collision with spacecraft material, and these much slower secondary particles, especially neutrons, are the real culprits that can be lethal to astronauts. Ways exist to deflect charged particles like high energy protons and solar alpha particles through active shielding technologies i.e., creating electromagnetic fields around the spacecraft artificially that can deflect them, but we have yet to devise ways protect us from neutral particles created by spallation, those energetic neutrons that are generated by secondary radiation.

Most talented engineers who build spacecraft are reticent about this show stopper, because they want to fly missions, like all of us, but NASA flight surgeons who have the final say and have to sign off on human missions, know that the risk is real. They know that state-of-the art technologies do not allow us, and it is futile to put our brave crew who are chomping at the bit to go, because they know exactly what will happen to them. They can even predict when their bodies will start to fall apart during transit, the point at which they will exceed the doses that humans can withstand without harm! Radiation doctors and professionals know that crew will perish during transit to Mars, and that we do not yet have the technology to protect them against GCR or anomalously large solar particle radiation storms, especially the dangerous, energetic secondary particle radiation that can cause a range of effects, from immediate crew impairment to slow and painful death.

We know full well the effects for radiation sickness and how systems shut down in death from our long and varied terrestrial experience with nuclear weapons development mishaps as well as nuclear reactor accidents like Chernobyl, and more recently from the crew who were exposed to deadly radiation from Fukushima reactor collapse and containment.

NASA has an active radiation monitoring and countermeasures program. For those wishing to dig a bit deeper, a quick look through their Man Systems Integration Standards(MSIS) will reveal enough gory and precise details of how the human physiology reacts to radiation and when the body starts to fail. Space radiation is the issue that pulled the plug on the daring Inspiration Mars mission, that recently proposed to put a crew on a free return trajectory on a flyby mission to Mars and back. The buck stopped at the NASA Astronaut Office, at the flight surgeon's desk, to be precise.

Experiments are underway on the international space station to ascertain what doses humans can handle. But once outside the Van Allen belts, the radiation environment is much more severe, as seen from the recent Curiosity rover that carries an active radiation monitor. It is clear we need better radiation protection for long expeditions, especially during transit, and we also need better data from deep space missions using biological samples (not crew !), yet to be manifest. We also know that radiation exposure during transit has a different pattern than on an extraterrestrial surface that blocks much of the GCR, due to the sheer mass of the planet. Again, the Moon, lacking a magnetic field blanket, offers the best site in our proximity to gauge the risk of long term solar particle radiation exposure as well as GCR, and the effects of deep isolation on crew, and is the ideal location to hone measures to combat these crucial issues.

All is not lost, though. We know that we can shield from this deadly radiation if our transit vehicles have thick enough shields of water. We also know that the tons of food and consumables for the expeditions as well as the large propellant tanks of Hydrogen could be configured as radiation shields around the crew compartment on these months long transits. Some engineers even think that water tanks would be the compact way to carry the propulsion reactants that could be manufactured as needed, enroute, both for outbound and inbound legs of such a long expedition. But once we get to Mars surface, how to survive the solar particle radiation that is quite high even there, on the surface? Unfortunately, we do not have an answer to this lethal issue yet !

To add to all the controversy to the exploration and settlement of Mars, is the issue of contamination and quarantine. Some scientists believe human activity on extraterrestrial bodies will endanger potential life forms that may exist there. And the search for life on Mars has only just begun. It may be decades before we know if there are life forms there or not. Until then, human activity may have to wait, if we are to follow their advice. There has not been much debate about this issue with regard to the "magnificent desolation" that is the surface of our Moon..

But all this begs the question: do we have to wait for technologies to develop, or are there worthwhile missions to do and gain invaluable experience while we get all these "good to have" technologies certified and commissioned for a Mars expedition ?

To be specific, are there space missions that can speed up technology evolution and inspire the public simultaneously while helping to fire up our STEM education and groom the next generation of explorers and engineers; missions that could also use space activity as sheer inspiration for our youth? The lure of the international space station seems to have run out of steam, at least among the public and the media. Space tourism may have some answers, perhaps ? And the US president's plan to send crew off to some unnamed asteroid for a nebulous and uninspiring mission seems to have weak and uninspiring support in Congress.

The Moon, on the other hand, offers all the excitement, now, as opposed to the next decade or the one after. A highly literally visible neighboring celestial neighbor is just three days away, and a dozen of our best and bravest have left their footprints there, not to mention their roving vehicles, some half century ago. NASA orbiting missions right now are providing the sharpest resolution imagery of the Moon as well as all the data, including radiation, for crew to quickly transit cislunar space and arrive at the destination. There are several nations at work right now, planning the next lunar missions. China has already landed a rover on the Moon. India was instrumental in locating water ice at the poles, that along with constant sunlight and mild surface temperatures all year round in the polar regions, could provide a stable setting for astronauts to learn to live and evolve systems for permanent settlements anywhere in the solar system.

And just for those scientists aiming for the next few decades of Nobel prizes, some of the finest scientific discoveries of great and immediate import to our species anywhere on the solar system is waiting for us on the Moon. The Moon, while we struggle to quilt solar activity information of the past few thousand years together, holds an unperturbed record of solar activity over the last few billion years, almost back to the genesis of our solar system and the formation of the Earth-Moon system, and this precious, nay priceless repository of information could tell us more about solar behavior over geologic time than any other body in our solar system. This data could be the defining element of the puzzle as we build reliable climate change models and shape our policies. To be explicit, Mars exploration cannot tell us that.



New technologies allow us to go back to the Moon at a fraction the cost of Apollo, and now, even private efforts like the Google X Prize contestants are underway to land and execute exploration missions there. There is even a private venture to establish a lunar observatory called the International Lunar Observatory Association (ILOA). NASA has not turned a blind eye to these activities. The Pacific International Space Center for Exploration Systems (PISCES) and their International Lunar Research Park initiative have been executing some groundbreaking simulations here on Earth, and NASA is looking at ways to integrate all these activities under a synergetic program umbrella at the Space Portal, a program developed at NASA Ames Research Center to facilitate such innovation and commercial interaction.

Now that NASA's Orion spacecraft is nearing commission and the large Space Launch System is nearly built, all eyes will be on building a lander that can service extraterrestrial surfaces. Rather than build it from scratch, NASA might do well to look at the effort well under way at SpaceX and at Blue Origin, that has proven it can do wonders with small business budgets and is about to land and reuse the first stage of its Falcon and New Shepard launchers. This technology lays the foundation for both lunar and Mars landers and can greatly speed up development.

Water ice, now conclusively detected in vast quantities the polar regions of our Moon is already changing the way we think of utilizing lunar resources. By processing this precious commodity that is regarded as the essential component for life, right there on the lunar surface, it is possible to provide breathable air, grow food, create rocket fuel and even use it in ingenious ways in currently proposed architectures and strategies to protect crew and biological matter from deadly radiation. Rocket fuel, which we now carry on spacecraft all the way to destinations and back for safe return have always been the most substantial mass and volume; a real drag on human space missions. The use of in situ water on the Moon to create liquid hydrogen and oxygen for return propulsion will completely change the way we fly sorties to the Moon, allowing us to carry much larger crew and payloads on landers that are then refueled on the lunar surface using fuel made locally. This is a giant step forward for any type of human mission beyond low Earth orbit, potentially opening the door for commercial, off Earth fuel production and distribution. Companies like Shackleton Energy are already vying for a first mover advantage in this new landscape for offering cheap and routine cislunar transportation, with direct ramifications for much more ambitious missions to Mars and the rest of the solar system.

Though scientific thought and religious enquiry seem to be at odds today in a world that seeks ever newer models of secular governance, humanity is still deeply rooted in spirituality, and religions continue to offer great organizing frameworks for modern societies. All great civilizations were founded and organized upon great religions and all cherished institutions of intellectual enquiry and education have places of worship in them. While two generations of engineers have been piling study upon study of how to build labs and accelerators and telescopes and other observatories on the Moon, thought leaders among civil architects and designers have been drawing plans for what they think we should do on the Moon for all humanity.

They propose time capsules, repositories including DNA banks, spiritual facilities and churches and temples and mosques. All of them are wary of economic development as we see it on Earth, bulldozers permanently scarring large swaths of land, and pollution everywhere. They are aware that the Moon, though desolate and barren, is even more fragile since it has no atmosphere or seasons or climate variations. Even the constant operation of rockets would be sufficient to forever alter the lunar landscape as we know it. So, we expect the pioneering lunar settlers to become far more sensitive in preserving the lunar environment than we do here on Earth, and develop and evolve the technologies to use resources accordingly. And developing such sensitivity toward nature and preservation of natural environments will have immediate and lasting consequence for all of us as stewards of planet Earth.

Sound space policy is built up from hard facts on the ground, and not on grand visions. The current US administration clearly sees the value of our space program as an instrument for both domestic and international policy. The Obama administration clearly sees the International Space Station as a golden goose that keeps on laying. Even though Russia seems at odds with current developments around the world, it seems unlikely that any of the partners will bail out of the agreements in place. There is a long waiting line of nations, chomping at the bit, to enter agreements and memoranda of understand-

ings to participate in the ISS program, even as the State Department courts capable nations like India and Brazil to extend the reach and influence of the US space program in international affairs.

So, in the prevailing global economic climate, there is no need at all for the current US administration to expand the effort to include any other visionary, new and ambitious projects like return to the Moon or Mars.

Two generations of our best and brightest engineers, now bordering on three, since Apollo, have spent their lives waiting to execute ambitious missions beyond low Earth orbit. Can we continue to postpone missions till we get all the right “good to have” technologies in place, as is the case for Mars, or do we execute missions that we can right now with existing technologies, as is the case for the Moon? It is important to remember that leading edge technologies tend to evaporate, if they are not put to good use in a timely manner. Also, the steady migration of our best and brightest to other progressive arenas of science and technology pursuits is inevitable, if we do not seize the opportunity to stretch the envelope in space activity development.

Is the space program all about Science, Technology, Engineering and Math(STEM), or is STEM just a byproduct of visionary space missions that strive to push the envelope of our skills using state-of-the-art technologies? These are the questions that our leaders need to be asking.

Unless governmental policy is articulated clearly, we will continue to vacillate about the visions and missions of our space program. Is this just about science, or technology or STEM ? or something much, much bigger ? Every visionary report has clearly suggested that human space activity at its core is about humans moving out into the solar system. It is really about extending civilization beyond Earth.

There will be false starts. The Panama Canal or the Euro Chunnel tunnel are examples of large endeavors that had to wait for generations for the right mix of technologies and politics. Starting a new, extraterrestrial branch of civilization will be much harder. Fall back options are surely much better, and political backlash from mission failure fewer, if we start this endeavor closer to home, on the Moon.

“Outta sight is outta mind” is still a powerful heuristic in human affairs. Mars is a speck in the night sky that is discernable to the experienced viewer, but the Moon is a very visible celestial disc that graces our skies every day, showing dynamic phases, with clear landmarks that are visible to all of humanity. As da Vinci so eloquently said about flight, so since we have been there, we yearn to go back.

If our wish is to learn to live on an extraterrestrial body, to establish an extraterrestrial permanent settlement now, as opposed to two decades and another lost generation of engineers, then we should be lining up our ducks and executing lunar missions aimed at settlement, starting right now. We should leverage the current excitement among spacefaring nations of the world and those who are willing partners to quickly seize the opportunity and make an international lunar settlement a priority and a reality.

It is very hard to predict the future. Logic had it that we would first establish an Earth orbiting station, and from there, go to the Moon. It turned out differently. The visionary idea of going back to the Moon, by helping other nations to do it is championed by astronauts like Buzz Aldrin. This is a unique arena of endeavor in which the US can reap a lot of good will quickly, globally. NASA is already supporting projects like PISCES here on Hawaii to this end.

The US can take the lead to establish a 21<sup>st</sup> century United Nations on the Moon, at a location from where the whole world can truly appreciate the fragile beauty of our biosphere. Or, as an Islamic student in my graduate studio proposed, we might help that great religion, for which the Moon is a symbol of worship, to build the ultimate mosque there. While scientists and astronomers contemplate large observatories, experiments and hazardous experiment laboratories on the Moon, recent architectural competitions have proposed spiritual facilities like monasteries and cathedrals, or even cemeteries and memorial monuments. Or perhaps, as some think, the Moon might be the best platform from which to launch and intercept an asteroid or cometary fragment that is headed for Earth impact with cataclysmic potential. From that vantage point, with our eyes on the Moon, Earthlings could be the real stewards of planet Earth, keeping guard, literally, round the planet, round the clock, from the heavens.

To sum up, civil architects use heuristics, or rules of thumb, to categorize complex and seemingly intractable problems, and often grapple with conflicting needs and requirements to create useful constructs. This is true for buildings and environments that shape our routines, or for cities and farms that support and nourish millions of lives. For space architects, those engineers who grapple with com-

plex problems associated with human space missions and extraterrestrial development, there are six "P"s that need to be clearly articulated before any mission can be undertaken to Mars. Clarity in the Policy of the administration and Protection of crew from space radiation are in the top rung of priority. Reliable Power(nuclear) and Propulsion for quick transit, landing and liftoff are key to any mission to the Moon or Mars. Unlike the past, the Private sector will play a backbone role in all space activity. Since Mars transit times are many months long and radiation damage to crew is cumulative, unless and until we find innovative ways to protect crew, or get to destinations quickly, Proximity is an overriding factor, and our destination is currently limited to the Moon, where we can get to quickly to the safety of the surface and settle underground, keeping space radiation in check.

The Policy wing of the administration is where alternative recommendations of advisory committees and expert groups are carefully weighed, priorities established, and the path to execution is finalized. The nature of this process often requires elimination of competing or conflicting goals. In the case of Moon or Mars, it is obvious that the Moon is the only viable goal that is executable right now.

Dangling the Mars carrot at the space community has had a retarding effect on progress because the technologies for sustaining a Mars mission cannot be achieved in a timely manner without hard data gleaned from extended Moon missions. By driving a wedge within the space community, it becomes harder to create consensus and focus efforts and budgets, when, in fact, we should be pursuing a vibrant series of missions, well planned and in sequence, that allows us to close all the strategic knowledge gaps with hard data from extended and ever more complex lunar missions that we can accomplish today.

More than five centuries ago, some brave explorers set sail across the ocean, in their most advanced technology wielding ships of their day, to discover and settle the American continent and eventually to lay the foundations and build up our great society. In this 21<sup>st</sup> century, the site for a truly bi-planetary civilization lies just three days away by rocketship. The Moon is about the size of Africa, a celestial continent with visible landmarks, waiting for settlement. We left our footprints and vehicles there some five decades ago. Many nations have ongoing missions or are currently charting plans and have ambitions to go there. Humanity can start to lay the building blocks for Planet Moon now, and the United States can play a shepherding role like we did with the ISS, but in an even grander scale, if we choose to. And in so doing, we can help the rest of the world aspire to a better future for all humanity, and also bring solar system resources into our sphere of influence and better prepare to settle the rest of the solar system.

There is a growing band of thought leaders who think we live in the Anthropocene era where human activities directly impact the fragile biosphere in irreversible ways, and a chorus who think the carrying capacity of the Earth has been reached. They feel that our species is contributing to rapid, detrimental changes in climate patterns and sustainable growth. Rather than continue to patch, fix and seek tweaks to economic activity, more and more people think we should move out into the solar system. With the human space program, perhaps this diaspora has already begun, and the Moon beckons us all to step out of the cradle of humanity and break free from what is otherwise a zero sum game for resources here on planet Earth, as we see today with our struggle for energy among the oil producing economic community of nations.

Soon after the dawn of the space age, some six decades ago, the utilization of space began with the orbital insertion of satellites that provide communications. Satellite communication systems have matured, and the satcom industry has evolved and thrived since. It is now a self sustaining business paying dividends to shareholders. The success of this endeavor has been such that satcom industry has defined the arc of history of space activity so far with discernable effects in the launcher industry that caters now exclusively to satellite payloads. Today however, the same spirit seems to be at work in the private manned space industry as private companies design and build heavy lift launchers to carry crew and equipment. A paradigm shift from open ended Space Exploration to profit oriented space utilization is clearly underway and perhaps the key to truly sustainable space activity.

Before long, it is possible, at the rate it is evolving, that private manned missions may replace government funded expeditions altogether, avoiding the huge bureaucratic hurdles that make projects like the international space station very cumbersome and expensive to administer. Perhaps a private Mars mission may happen before a government funded one ?

If it were just about flags and footprints, yes, we have been to the Moon, and yes, we should plant another flag on Mars. But space activity is not about just flexing a nation's technologic prowess or open ended space exploration anymore. It is truly about extending our species outward into the cosmos, (extending our economic sphere of influence as the former director of OSTP USC professor John Marburger mentioned in his 2006 Goddard Memorial keynote address ) and about building serviceable pathways to celestial destinations for all humanity to settle and thrive, to live long and prosper, as the beloved, recently departed Mr.Spock( Leonard Nimoy) might say.

So, is it the Moon or Mars ? Those economic bean counters argue it is all about money. But there is also a well known counterpoint that says that when all the talk is about money, it is really not about money. Could it be that we, as a species, are running bankrupt on the imagination front ? There is a less known heuristic that architects employ with great effect. When offered a choice, take both. And it has served them well. In this case, return to the Moon now could be the natural precursor and catalyst for a Mars expedition and for much more ambitious missions to come. MT

## A New Moon-Focused Organization



### Getting Going Moonwards

By Kim Holder

**Moonwards, a special Interest Chapter of the National Space Society is being set up – Its purpose is “to advance settlement of the Moon by giving the public a sense of what it would be like to live there, and what it could mean.”**

We have ways to do that now that give a whole new scope to the endeavor. These are the days of World of Warcraft, Minecraft, Eve Online.

### **Moonwards principal project will be to create a virtual Moon colony, and make it as real as possible.**

It will be a plausible, viable Moon settlement, as it could be in a few decades if energy was put into creating one. It will be true to the reality, to the science. It will start as a digital model sited in an accurate depiction of a particular place on the Moon. And it will grow from there.

There are so many ways it could grow with time. There are so many fans of space settlement out there who have skills that would make it an engaging, fun, rich place to be on-line. Bring us your ideas and energy, and let's make it a springboard into the future. Let us show the world what space can be.

**Among first recruits:** Dave Dunlop, Al Anzaldua, Peter Kokh.

If you would like to participate, please send an email to [nssmoonwards@gmail.com](mailto:nssmoonwards@gmail.com) .

Watch for the launch of [www.moonwards.com](http://www.moonwards.com) , where you can find out more.





## International Space Advocacy Organizations Encouraging Student Participation

### **National Space Society (US) – <http://www.nss.org> – NSS**

NSS currently has chapters in Australia, Canada, Germany, France, Netherlands, Brazil, and India  
<http://www.nss.org> – <http://chapters.nss.org/a/lists/>

### **NSS' International Space Development Conference – ISDC**

The “ISDC” is usually held the weekend of the last Monday in May (Memorial Day weekend) in various locations, hosts students from around the world, many of them presenting their entries to NASA’s annual Space Settlement Design Contest. Usually, The Moon Society and SEDS participate in this conference.  
<http://isdc.nss.org>

### **The Moon Society – <http://www.moonsociety.org> – TMS**

The Moon Society has informal relationships with the Calgary Space Workers, Calgary, Alberta, Canada and with the Sociedad Espacial Mexicano, Mexico. The Society has members in many countries.

### **Students for the Exploration and Development of Space – SEDS – <http://www.seds.org>**

SEDS has had greater success setting up chapters around the World than any other Space organization. How to Start a SEDS Chapter – [http://wiki.seds.org/index.php?title=Start\\_a\\_SEDS\\_Chapter](http://wiki.seds.org/index.php?title=Start_a_SEDS_Chapter)  
<http://seds.org/chair/ChapterExpansionKit30.pdf>

### **SEDS–Earth – <http://earth.seds.org/index.php> – This is the international chapter.**

There are chapters of SEDS around the world: (USA), **India, Nigeria, United Kingdom, Philippines**, and more; SEDS–Earth is a central node for communication between these worldwide chapters.

### **Space Renaissance Initiative – <http://www.spacerenaissance.org>**

SRI’s focus is on use of space resources to address the challenges of runaway population growth and increasing use of Earth resources at a non-sustainable pace. “The settlement of space would benefit all of humanity by opening a new frontier, energizing society, providing room and resources for the growth of the human race without despoiling Earth, creating a lifeboat for humanity that could survive even a planet-wide catastrophe.”

### **The Mars Foundation – <http://marsfoundation.org/> – <http://marshome.org/>**

The Foundation seeks to involve interested persons in the design of Mars outposts and settlements, maximizing use of building materials that can be produced on Mars, to illustrate the near-term feasibility of establishing a permanent human presence on Mars.

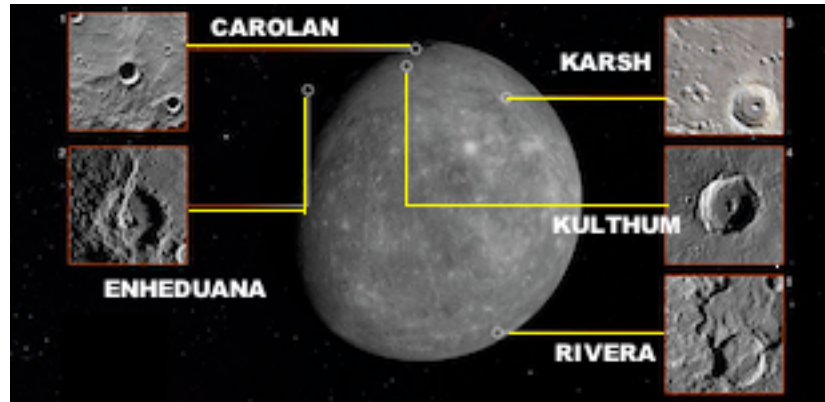
### **Open Luna Foundation – <http://openluna.org/missions>**

The OpenLuna Foundation aims to return to the moon through private enterprise. A stepped program of robotic missions, then a short series of manned missions to construct a small, approximately 8 person outpost.

### **The Planetary Society – [http://www.](http://www.ThePlanetarySociety.org) The Planetary Society**

## Winners of a Contest to name 5 new craters on Mercury

1 May, 2015 – [www.space.com/29283-mercury-crater-name-contest-winners.html](http://www.space.com/29283-mercury-crater-name-contest-winners.html)



Just hours before NASA's MESSENGER spacecraft was expected to crash onto the surface of Mercury, ending the probe's 4-year observation of the innermost planet, the winners of a contest to name five new craters on Mercury were announced.

- The five winning crater names are: **Carolán, Enheduanna, Karsh, Kulthum** and **Rivera**.
- The names were selected by the public outreach team for the spacecraft out of thousands of submissions to an open competition that closed in January. MESSENGER crashed into the surface of the planet at 3:26 p.m. EDT (1926 GMT) April 30, 2015
- The new crater names have been approved by the International Astronomical Union (IAU).
- The rules of the IAU state that Mercury features must be named after an **artist, composer or writer** who was **famous for more than 50 years** and **died at least three years ago**.
- Out of 3,600 entries, a semifinal list of 17 names.
- Anyone in the world could make entries, up to Jan. 15.
- These are the people who the craters were named after and the people who submitted those names:
  - Turlough O'**Carolán** was an Irish composer in the late 16th and early 17th centuries. The name was suggested by Fergal Donnelly (Belgium), Joseph Brusseau (United States) and Deane Morrison (United States).
  - **Enheduanna**, a princess of the Sumerian city of Ur in ancient Mesopotamia (modern Iraq and Kuwait), is the first known poet and author. The name was suggested by Gagan Toor (India).
  - Yousuf **Karsh**, an Armenian-Canadian, was a famous portrait photographer in the 20th century. Elizabeth Freeman Rosenzweig (United States).
  - Umm **Kulthum**, an Egyptian singer, songwriter and film actress, who was known for her work between the 1920s and the 1970s. The name was suggested by Molouk Ba-Isa (Saudi Arabia), Riana Rakotoarimanana (Switzerland), Yehya Hassouna (United States), David Suttles (United States), Thorayya Said Giovannelli (United States) and Matt Giovannelli (United States).
  - Diego **Rivera**, a Mexican painter and muralist, who was active between the 1920s and 1950s. The name was suggested by Ricardo Martinez (Mexico), Rebecca Hare (United States), Arturo Gutierrez (Mexico) and José Martinez (United States).

## Send Your Drawing into Space with CHEOPS

[www.esa.int/Our\\_Activities/Space\\_Science/Send\\_your\\_drawing\\_into\\_space\\_with\\_Cheops](http://www.esa.int/Our_Activities/Space_Science/Send_your_drawing_into_space_with_Cheops)

6 May 2015 - You can send your art into space on the new Cheops satellite. ESA and its partners are inviting children to submit drawings to be miniaturised and engraved on two plaques that will be put on the satellite. **Cheops** - for **CH**aracterising **ExO**Planets **S**atellite - is a space telescope that will observe nearby stars known to host planets, and is being built as a collaboration between ESA's Science Programme and Switzerland. The planned launch date is at the end of 2017.

With the data from Cheops, astronomers will be able to characterise the sizes and masses of many ex-trasolar planets, to gain new insights into the formation of planetary systems.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



Do you want to send your art into space on the new Cheops satellite? ESA and its mission partners are inviting children to submit drawings that will be miniaturised and engraved on two plaques that will be put on the satellite.

Children between from 8–4 from any ESA member state or cooperating state can be part of this otherworldly enterprise by creating a drawing inspired by the mission.

The artworks **must be in black-and-white**, created with a **black pencil or felt-tip pen** to ensure that the engraving process accurately captures the drawings to be transferred to the metal plaques.

Up to 3000 drawings will be shrunk down by a factor of about 1000 and engraved on the metal plaques that will fly into space on Cheops. If more than 3000 entries are received, there will organise a lottery to select the drawings for engraving.

To take part in this competition, you must download and print out a standard template provided [here](#), make your drawing on it, and complete your contact details. Then send it via letter to either your local Cheops mission partner institution, if there is one in your home country, or to ESA directly.

Entries will be postmarked by 31 October 2015.

This competition is an initiative of the University of Bern, Switzerland, the overall coordinator of the activity. Mission partner institutions in the countries that are part of the Cheops consortium (Austria, Belgium, France, Germany, Hungary, Italy, Portugal, Spain, Sweden, Switzerland and the UK) are also open for entries, as is ESA directly, representing all of its member states.

**Full rules, terms, and conditions can be found below**

[http://www.esa.int/Our\\_Activities/Space\\_Science/Send\\_your\\_drawing\\_into\\_space\\_with\\_Cheops\\_Rules](http://www.esa.int/Our_Activities/Space_Science/Send_your_drawing_into_space_with_Cheops_Rules)

The standard template for the drawings can be found

**Contacts and mail addresses for the national competitions**

[www.esa.int/Our\\_Activities/Space\\_Science/Send\\_your\\_drawing\\_into\\_space\\_with\\_Cheops\\_National\\_contacts](http://www.esa.int/Our_Activities/Space_Science/Send_your_drawing_into_space_with_Cheops_National_contacts)

**Contacts and mail addresses for the national competitions** [here](#). (PDF FILE)

**Feedback questionnaire about the competition (optional)** [here](#). (PDF FILE) ##

## NASA Contest Wants Your Ideas to Keep Astronauts Safe on Mars

7 May, 2015 - [www.space.com/29345-nasa-journey-to-mars-challenge.html](http://www.space.com/29345-nasa-journey-to-mars-challenge.html)

<https://www.innocentive.com/pavilion/NASA>.

To prepare for future colonies on Mars, NASA is asking the public for ideas on how to keep Red Planet astronauts safe that **require minimal resupplies** from Earth.

The "Journey to Mars Challenge" will give a \$5,000 award **to each of the three winning participants** who describe an original idea that could assist the human exploration of Mars. The proposal must be "**√ technically achievable, √ economically sustainable, and √ minimize reliance on support from Earth**," NASA wrote in a statement about the challenge.

This could include **shelter, food, water, breathable air, communication, exercise, social interactions and medicine**, but participants are **encouraged to consider innovative and creative elements beyond these examples**." Because launch costs are considered one of the key barriers to space explora-

tion generally — and Mars exploration, especially — NASA says it could use **some ideas on what to bring on these missions and how often to resupply them.**

The **resupply aspect is especially important** because resupply opportunities to Mars would happen only every 500 days; the respective orbits between Earth and Mars line up infrequently. By contrast, the International Space Station has resupplies every few weeks or months.

The agency is looking for **ideas backed up by a strategy** — "a process to develop, test, implement and operate the system or capability."

The "Journey to Mars" challenge was announced the same week as the Humans to Mars Summit in Washington, D.C., a conference in which NASA is participating. Experts at the summit are considering the best ways to bring humans to Mars affordably within the next few decades.

In recent months, NASA publicly repositioned its human exploration program as a series of stepping stones to Mars. ##

## NASA Names Winners of Student Launch Challenge

15 May, 2015 – [www.nasa.gov/press-release/nasa-names-winners-of-student-launch-challenge](http://www.nasa.gov/press-release/nasa-names-winners-of-student-launch-challenge)

For the third year in a row, Vanderbilt University of Nashville, Tennessee has been named the winning team in the NASA Student Launch challenge, earning the \$5,000 prize.

- The prize purse for the challenge, on April 11, was provided by corporate sponsor Orbital ATK of Promontory, Utah.
- Teams from the **University of Louisville**, Kentucky and the **University of North Carolina**, Charlotte won second and third place, respectively. The 2015 Rookie of the Year award was presented to the University of Massachusetts Amherst.
- Student Launch is a competitive learning opportunity for teams of students from middle school to university level to conduct research and development in rocket propulsion systems. Students spend eight months designing, building and testing small high-powered rockets, scientific payloads and/or ground support equipment using the same launch criteria as NASA.
- "Student Launch enables teams to research innovative solutions to technical problems, which could potentially advance future NASA missions," said Tammy Rowan, manager of the Academic Affairs Office at NASA's Marshall Space Flight Center in Huntsville, Alabama. "Students demonstrate advanced concepts of 3-D printing, carbon-fiber engineering and autonomous systems, all which may benefit NASA exploration or the development of new aerospace industry or products."
- Thirty-five teams, from 18 states and Puerto Rico, launched their single-stage rockets during the 15th annual competition held near Marshall. To determine the winning teams, data from each of the flights was analyzed over the following weeks and the results of the analyses were combined with results from technical design reviews and other products required before launch day.
- NASA and Orbital ATK presented a variety of preliminary awards during an April 10 banquet at the U.S. Space & Rocket Center in Huntsville.

## Robots Face Off in \$1.5 Million NASA's 4th Sample Return Challenge

13 June, 2015 – [www.space.com/29657-nasa-sample-return-robot-challenge-2015.html](http://www.space.com/29657-nasa-sample-return-robot-challenge-2015.html)

Robot-toting teams faced off in a NASA contest this week to see which automaton has the right stuff for working on Mars or other locations in the solar system.

The challenge offered a grand prize of \$1.5 million to the winning team able to **demonstrate robots that can collect geologic samples without any human help at all.**

- Developing technologies in autonomous navigation & robotic dexterity is one of the main goals.
- The teams include universities and small businesses faced off all week at Worcester Polytechnic Institute in Worcester, Mass.
- Robots are our pioneers, and solving this challenge will be a breakthrough for future space missions. There are two levels of competition this year. In 2013 and 2014, the winners of Level 1 – Team Survey of Los Angeles in 2013 and the West Virginia Mountaineers of Morgantown – each received \$5,000. These teams can each compete at Level 2 this year.

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and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



**Other returning teams include:**

- Formicarum of Worcester, Massachusetts
- Gather of Alexandria, Virginia
- Lunamobotics of Mexico City
- Middleman of Dunedin, Florida.
- Oregon State University of Corvallis
- The Retrievers of Schenectady, New York
- Rensselaer Polytechnic Institute Rock Raiders of Troy, New York
- Wunderkammer of Topanga, California

**New teams in 2015 are:**

- Army of Angry Robots of Silicon Valley, California
- DT Bozzelli of Ann Arbor, Michigan
- MAXed OUT of San Jose, California
- Mind and Iron of Needham, Massachusetts
- Massachusetts Institute of Technology Robotics Team of Cambridge
- RoboRetrievers of Tampa, Florida
- Sirius of South Hadley, Massachusetts
- Smart Move of Clearwater, Florida
- Smart Tools of Gurnee, Illinois
- National Autonomous University of Mexico

## NASA Awards \$100,000 to Winning Team of Robot Challenge

[www.nasa.gov/press-release/nasa-awards-100000-to-winning-team-of-robot-challenge](http://www.nasa.gov/press-release/nasa-awards-100000-to-winning-team-of-robot-challenge)

13 June, 2015 –

- NASA has awarded \$100,000 in prize money to the **Mountaineers**, a team from **West Virginia University, Morgantown**, for successfully completing Level 2 of the Sample Return Robot Challenge, part of the agency's Centennial Challenges prize program.
- Worcester Polytechnic Institute (WPI) hosted the event June 10–12 at its Worcester, Massachusetts, campus. This was the fourth year NASA and WPI held the Sample Robot Return competition.
- The award was made at the opening of TouchTomorrow, a science and robotics technology festival. The festival, which was open to the public, highlighted the teams and robots, as well as NASA and WPI exhibits in science, robotics and space technology.
- The objective is **to encourage innovations in autonomous navigation and robotics technologies**.
- Teams were required to demonstrate their robots could locate and collect geologic samples from wide and varied terrains, operating without human control.
- Two levels of competition: to complete Level 1 successfully, the robot must depart a starting platform in search of a sample, the specifications of which were previously programmed into the robot's on-board computer. Operating autonomously, the robot has 30 minutes to locate, capture and return to its starting platform with one undamaged sample. Teams completing Level 1 may move on to Level 2.
- For Level 2, robots had two hours to return autonomously at least two undamaged samples, including a sample known previously to the team and one introduced the day of the competition.
- Samples collected in Level 2 are categorized as easy, intermediate and hard based on the complexity of their shape, size and design. More points are awarded for those classified as hard.
- In this year's competition, samples ranged in shape and size from rectangular to round.
- The Centennial Challenges program is part of NASA's Space Technology Mission Directorate, which is innovating, developing, testing and flying hardware for use in NASA's future missions. For more information, visit: <http://www.nasa.gov/challenges>

## High School Student Discovers Alien Planet

11 June, 2015 – [www.space.com/29630-high-school-student-discovers-exoplanet.html](http://www.space.com/29630-high-school-student-discovers-exoplanet.html)

An English high school student has become perhaps the youngest person ever to discover an alien planet. Fifteen-year-old Tom Wagg first detected the gas-giant exoplanet two years ago, while doing work-experience study at Keele University in England.



- Further observations have now confirmed the existence of the alien world, which lies about 1,000 light-years from Earth and is known as **WASP-142b**. "I'm hugely excited to have found a new planet, and I'm very impressed that we can find them so far away," said Wagg, now 17.
- Wagg analyzed data gathered by the **Wide Angle Search for Planets (WASP) project**, looking for tiny dips in stars' brightness caused by planets passing in front of them.
- This strategy, known as **the transit method**, is the same one used by NASA's Kepler spacecraft which has discovered more than half of the roughly 1,900 known exoplanets to date.
- **WASP-142b is a "hot Jupiter"** – about the same size as our solar system's largest planet
- But it lies extremely close to its host star, completing one orbit every two days.
- Scientists think hot Jupiters form relatively far from their parent stars, then migrate inward over time as the result of gravitational interactions with other planets.
- Wagg, a student at the Newcastle-under-Lyme School in the English county of Staffordshire, plans to study physics when he attends university. He asked to participate in the work-study program at Keele after learning that the university hosts a research group focused on exoplanets.
- Wagg's detection of WASP-142b was confirmed by astronomers based at the University of Geneva in Switzerland and University of Liege in Belgium, researchers said. ##

## The Grand Canyon Star Party: Illuminating Dark Skies

19 June, 2015 – [www.space.com/29714-grand-canyon-star-party.html](http://www.space.com/29714-grand-canyon-star-party.html)

[www.space.com/29710-milky-way-trails-over-grand-canyon-star-party-in-time-lapse-video.html](http://www.space.com/29710-milky-way-trails-over-grand-canyon-star-party-in-time-lapse-video.html)

Grand Canyon National Park has some of the clearest night skies in Arizona, hours away from urban environments and thousands of feet above sea level.

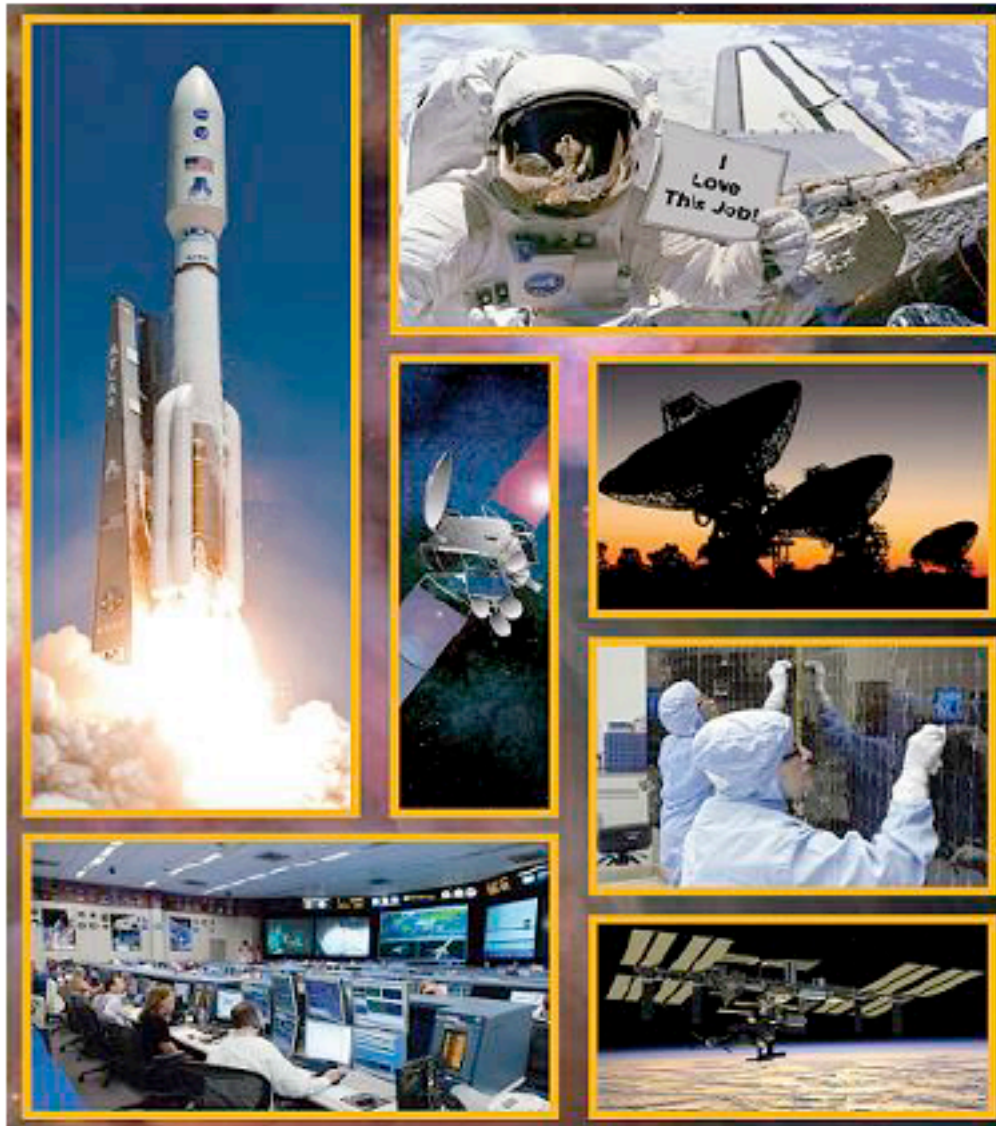
- In the late 1970s, the San Francisco Sidewalk Astronomers began setting up telescopes in the park for public use, with Twilight Talks and sunset introductory astronomy lectures, while amateur astronomers set up their telescopes.
- After one of the talks went on a tangent about evolution, complaints forced the site to revoke permission for the event, and the large star parties disappeared from the Grand Canyon — for a time.
- In 1990, Dean Ketelsen, technical expert at U. Arizona's Steward Observatory, passed through the Grand Canyon in 1990 with a pair of large, high-power Japanese battleship binoculars originally built to see ships on the ocean's horizon, luring a line of tourists. The result was the first Grand Canyon Star Party in 1991, held one week in June every year at both the south and north rims of the Grand Canyon.
- Many people don't get to see wilderness skies; they're lucky to see just a few stars in light polluted urban areas. The star party provides people a chance to get a perspective on our place in the universe.
- Grand Canyon National Park boasts one of the last remaining dark skies in this country.
- Now with the internet and the following of regulars to the event, it basically sets itself up as a great resource for the park, and a summer vacation tradition.
- "Whether someone comes just to appreciate the beauty of the sky or has an affinity for the science involved, the information the sky provides opens horizons to the definition of life." ##

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LOOKING FOR A SPACE-RELATED CAREER?

Check out this book

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High-res copy of front cover: [www.spacebusiness.com/careers/978-1-887022-19-4.jpg](http://www.spacebusiness.com/careers/978-1-887022-19-4.jpg)  
[www.spacebusiness.com/careers](http://www.spacebusiness.com/careers)

Fully-updated for 2015, the book is **designed for high school, college, graduate students,** as well as **job seekers** interested in **opportunities that the space and satellite industry.**

Whether the reader is interested in satellite communications services, designing next generation rockets, planning future Mars missions, or monitoring the Earth's environment, **Space Careers** will be a valued resource.

**It does the work so you don't have to.**

But this book offers more than just a compilation of facts and data. Throughout the book is valuable advice to students and job seekers provided by leading industry professionals including Marillyn Hewson, the President & CEO of Lockheed Martin; Charles Bolden, the administrator of NASA; as well as engineers, scientists, and businesspeople working in the field.

**Space Careers** is a resource that needs to be shared, read, and used by students, educators, and people working in the STEM/STEAM fields [Science, Technology, Engineering, [Art] & Mathematics]. With the industry seeking to identify and entice the next generation of workers, companies and institutions need to make this valuable resource available. ##

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



## 'Skyglow' Kickstarter Takes On Light Pollution of the Night Sky



The **bright urbanized areas** show where **light pollution** is worst.

8 May, 2015 – [www.space.com/29346-light-pollution-skyglow-kickstarter.html](http://www.space.com/29346-light-pollution-skyglow-kickstarter.html)

[www.space.com/29347-skyglow-team-s-night-sky-time-lapses-amaze-and-educate-video.html](http://www.space.com/29347-skyglow-team-s-night-sky-time-lapses-amaze-and-educate-video.html)

After spending years wowing the astronomy world with gorgeous time-lapse views of the stars, two astrophotographers have teamed up for a new project: raising awareness of light pollution.

Gavin Heffernan and Harun Mehmedinovic hope to raise \$70,000 via a Kickstarter crowdfunding campaign to create an astrophotography book and a **video** time-lapse series showing dark skies in the United States and Canada. The project, which closes Sunday (May 10), is called SKYGLOW, a term referring to the brightening caused by light pollution. Watch a **video of how SKYGLOW will work here**.

Heffernan, who lives in Southern California, said that the lights of Los Angeles clearly show up in time exposure pictures taken from 150 miles (240 kilometers) away. He said the need to avoid such light-polluted areas sparked a discussion that led to SKYGLOW.

Most of the money raised during the Kickstarter campaign will go to printing and shipping the books to an estimated 3,000 people, with the remainder budgeted for a trip through the United States and Canada to take pictures from various spots, including **dark-sky preserves**.

With \$55,000 raised as of May 7, 2015, the project may not end up being funded, Mehmedinovic acknowledged. However, the effort will at least raise awareness about the effects of light pollution, which not only hinders skywatching but has also been traced to changes in animal activity.'

"Even if we don't succeed," Mehmedinovic said, "we still have something because of awareness of the issue. We have appealed directly to the people and not some middle person."

A typical shoot requires f5-7 cameras between the two photographers, a number called for due to the quantity of pictures taken. A time lapse of just 10-20 seconds incorporates 250 to 450 images.

A time-lapse project can easily fill up a 4-terabyte hard drive, enough space for a typical consumer to store hundreds of movies. Once the images are taken, they have to be processed and then exported through more software before being uploaded to the Web.

You can view the Kickstarter campaign at [www.skyglowproject.com](http://www.skyglowproject.com). More information on the project is available at [www.sunchaserpictures.com/](http://www.sunchaserpictures.com/) and [www.bloodhoney.com/](http://www.bloodhoney.com/), the personal websites of Heffernan and Mehmedinovic, respectively.

**Editor:** We put this story in the **Students & Teachers Section**, because it's **your right to see and enjoy** what people everywhere were once able to do, but that the past generations, by being complacent, are letting slide into "the good old days."

It is you who have to fight to keep that right, and to keep in touch with the heavens above where mankind's future lies.

Yes pink uplit clouds at night can be pretty, but they are no comparison to the splendor they hide.

**Organize a "clear skies" campaign** to fight to reduce nighttime light pollution where you live!



**Relevant Light Pollution links:**

[http://en.wikipedia.org/wiki/Light\\_pollution](http://en.wikipedia.org/wiki/Light_pollution)

International Dark Sky Association – <http://www.darksky.org/>

The Night Sky in the World – <http://www.lightpollution.it/dmsp/>

Eastern USA, Central Europe, Japan are by far the worst! <http://www.lightpollution.it/worldatlas/pages/fig1.htm>

<http://www.starrynightlights.com/lpIndex.html>

For relevant Videos enter “light pollution of night skies videos” in Google Search

Needless Light Pollution – <http://www.need-less.org.uk/>

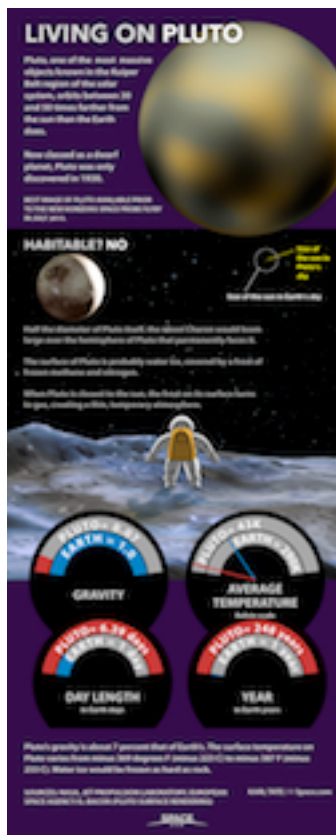
Light pollution dulls the night sky for stargazers – and drains city funds

<http://news.medill.northwestern.edu/chicago/news.aspx?id=165102>

**Space.com “Infographics” – How to learn a lot about 150+ Space-related topics**

**Some Current Examples**

<http://www.space.com/infographics/>



Click on the infographic link at top of page to see these and other infographics at full size

**Waypaver University – coming soon**

[www.waypaverlabs.org/programs/waypaver-university/](http://www.waypaverlabs.org/programs/waypaver-university/)

**Attention Lunar Analog and Lunar Base fans:**

Will Pomerantz, Sara Jennings, and others are part of a new lunar research park being set up. Starting a new space college rather like Kepler University

## Time Capsule to Mars™ New Partnership –Savannah College of Art & Design

### Student team to lead creative direction & content development for historic mission to Mars - [www.timecapsuletomars.com](http://www.timecapsuletomars.com)

DURHAM, NC – May 6, 2015 – An **undergraduate team of eight students** is boldly taking the **Savannah College of Art & Design (SCAD)** where it has never gone before -- to Mars, as an official university partner within the **Time Capsule to Mars™ (TC2M)** network.

The SCAD team will lead the creative vision for TC2M's brand, **develop graphic design elements for communication, and create the digital media tools and content for the mission.**

TC2M, an [Explore Mars](#) BE BOLD Technical Project, is a student-led project that is designing, building, launching, and landing the first privately-funded mission to Mars by 2018.

Undergraduate/graduate teams from across the United States are on board, and technical development is well underway. **The spacecraft will carry digital content uploaded by individuals from around the world for a small fee to be sent to Mars for future human explorers to recover.**

Every aspect of this mission will be led and developed by students

SCAD fills a critical need for the mission

[www.timecapsuletomars.com](http://www.timecapsuletomars.com) upgrade

The student team at SCAD has begun work on web content that will be used for donor and consumer outreach. The team is addressing an overhaul of [www.timecapsuletomars.com](http://www.timecapsuletomars.com), a **crowdfunding campaign video**, and **other content** within the project's integrated marketing strategy.

SCAD will also be leading **the design and optimization of the mission's user experience.**

"As a team we consider this a great chance to not only learn and build our skillsets, but also a great opportunity to collaborate with very talented students from other fields and schools."

#### Students involved in the project at SCAD

come from a variety of different majors, including **graphic design, industrial design, interaction design, service design**, and film & television.

Throughout the mission, new students will come on board as others graduate.

"This is an inspirational project for our school that allows our students to practice their skills on their way to market-facing jobs"

"Over the course of the mission, we will build the TC2M team's objectives into our coursework and extracurriculars so that as many students can take part as possible."

SCAD joins **Duke University, Embry-Riddle Aeronautical University, Florida Institute of Technology, Georgia Institute of Technology, Massachusetts Institute of Technology (MIT), Stanford University, University of Colorado at Boulder, and University of Connecticut** in bringing the mission to a successful landing in 2018.

#### About Time Capsule to Mars™

**The world's first student-led interplanetary mission,  
Will design, launch and land intact a time capsule on Mars**

containing digital messages representing a snapshot of humanity on Earth

**To inspire today's generation, and commit to sending humans to Mars who will recover the capsule.**

TC2M intends to be one of the largest crowdfunded endeavors, aiming to raise \$25 million.

[TC2M is a project of the non-profit **Explore Mars, Inc.**]

Read more about our mission at:

[www.timecapsuletomars.com/?utm\\_source=Explore+Mars+Newsletter](http://www.timecapsuletomars.com/?utm_source=Explore+Mars+Newsletter)

follow us on Twitter [@TimeCapsuleMars](#) or [#TC2M](#), and on [Facebook](#).

## Students Compete to Design Manned Asteroid Mission

13 May, 2015 - [www.space.com/29390-students-compete-to-design-manned-asteroid-mission.html](http://www.space.com/29390-students-compete-to-design-manned-asteroid-mission.html)

32 students from 14 countries around the world, picked from over 200 applications from 110 universities in 19 countries, came together recently to map out a manned mission to a captured asteroid in lunar orbit — such as NASA hopes to bring there from an orbit further out by 2025.

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)

- The students gathered in late March for the weeklong "2015 Space Challenge", hosted by the Keck Institute for Space Studies (KISS) at the California Institute of Technology in Pasadena.
- The event culminated in a **winning asteroid mission design** on March 27.
- The group of students was split into **two teams: Explorer and Voyager**.
- Each team had a diverse set of talents.



Above: Members of Team Explorer give a spirited cheer as they record their team video

- Most of the participants had an engineering background,
- A smaller number have varied scientific backgrounds, such as physics and geology.
- One student is studying space architecture [at] Columbia [University]."

#### Getting down to business

- Each team was given the basic ingredients of a crewed asteroid sample mission
- A sample from a type-C [carbonaceous] asteroid would be delivered via robotic probe to an orbit about 61,500 km [38,214 mi] from the Moon.
- The crew will have to interact with the asteroid sample, do resource extraction and **in-situ resource utilization** {"in situ" is Latin for "on site" – a term that puts space scientists above the rest of us}.
- The challenge mirrors NASA's real **Asteroid Redirect Mission**, which aims to pluck a boulder off a near-Earth asteroid using a robotic probe, then drag the rock into orbit around the moon. Astronauts would then visit the asteroid chunk by 2025.
- During the first few days, both teams received background instructions from a variety of speakers
- Once they were primed with enough information, the teams went to work in their classrooms.
- The first order of business was to sort out their roles within the working group.
- Each team was responsible for figuring out their own decision-making structure.
- They split themselves into smaller teams, subsystems, and team leaders
- The teamwork is very important. The students involved have so many different backgrounds
- They spent 12-hour days working together."
- The intense real-world structure of the exercise impressed the participants.

#### The designs

- On day six, the teams wrapped up their efforts and completed their reports. At midday, the participants filed into an auditorium to give their presentations and turn in their reports.
- For both teams, crew safety and operational autonomy were high priorities.
- "On-site" extraction of resources and demonstrations of the utility of those resources were stressed. Team Explorer planned to grow lettuce in asteroid soil, and outlined plans for a steam-powered rocket fueled by ice found on the asteroid.
- Their mission would last 22 days.
- Team Voyager laid out a similar proposal, opting for a 39-day expedition.

#### Choosing the Winning Team

- After the presentations, questions came from the audience and the jurors who would choose a winner.

#### Conclusion

- The event concluded with an awards banquet that evening. Team Voyager took the prize.
- In the end, the students came away with a true appreciation for what they had accomplished and the impact they hope to make on future space travel.
- More information on the Caltech Space Challenge can be found at [www.spacechallenge.caltech.edu](http://www.spacechallenge.caltech.edu) ##

This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miw](http://www.nss.org/tothestars/miw)cepts

## 3D Printed Habitat Challenge: Solving the need for safe, secure and sustainable housing on Earth and Beyond

[http://www.nasa.gov/directorates/spacetech/centennial\\_challenges/3DPHab/index.html](http://www.nasa.gov/directorates/spacetech/centennial_challenges/3DPHab/index.html)

**NASA and the National Additive Manufacturing Innovation Institute, known as America Makes, are holding a new \$2.25 million competition to design and build a 3-D printed habitat for deep space exploration, including the agency's journey to Mars.**

The multi-phase 3-D Printed Habitat Challenge is part of NASA's Centennial Challenges program, and **designed to advance the additive construction technology needed to create sustainable housing solutions for Earth and beyond.**

**The 1st phase** of the competition runs through Sept. 27 and calls on participants to develop state-of-the-art architectural concepts that take advantage of the unique capabilities 3-D printing offers. The top 30 submissions will be judged and a prize purse of \$50,000 will be awarded at the 2015 World Maker Faire in New York.

**The 2nd phase** is divided into **The Structural Member Competition (Level 1)** focused on the fabrication technologies needed to manufacture structural components from a combination of indigenous materials and recyclables, or indigenous materials alone. **The On-Site Habitat Competition (Level 2)** challenges competitors to fabricate full-scale habitats using indigenous materials or indigenous materials combined with recyclables. Registration opens Sept. 26 Each carries a \$1.1 million prize.

For more information, rules and to register for the 3-D-Printed Habitat Challenge, check here: <https://americamakes.us/Challenge>

**Main Challenge Page:** <https://americamakes.us/Challenge>

<https://americamakes.us/challenge/from-waste-to-space-the-3d-printed-habitat-challenge/>

<https://americamakes.us/challenge/references/> - <https://twitter.com/3DPChallenge>

Deadline July 15 to submit the registration package for our [@3DPChallenge](#) with [@NASAPrize](#).

### Publicity

[www.kurzweilai.net/nasa-challenges-makers-to-design-3-d-printed-habitats-for-deep-space-exploration](http://www.kurzweilai.net/nasa-challenges-makers-to-design-3-d-printed-habitats-for-deep-space-exploration)

<http://www.engadget.com/2015/05/16/nasa-3d-printed-habitat-competition/>

<http://makezine.com/2015/05/16/announcing-nasas-3d-printed-habitat-challenge/>

<http://www.treehugger.com/gadgets/nasa-holding-225-million-design-competition-deep-space-3-d-printed-habitat.html>

## Student Experiments Fly High in Sounding Rocket

28 June, 2015 - [www.space.com/29778-student-experiments-nasa-suborbital-rocket.html](http://www.space.com/29778-student-experiments-nasa-suborbital-rocket.html)

A NASA suborbital sounding rocket filled with student experiments flew more than 114 km (71 mi) high June 25.

- The **NASA Terrier Improved Orion rocket** launched from the space agency's Wallops Flight Facility in Virginia, carrying payloads built and designed by students participating in two national student rocketry programs, RockOn and RockSat-C. More than 200 middle school and university students came out to watch the launch.
  - Through RockOn and RockSat-C, students are learning and applying skills required to develop experiments for suborbital rocket flight. In addition, middle school educators through the Wallops Rocket Academy for Teachers (WRATS) are learning about applying rocketry basics in their curriculum. Both programs of the Colorado Space Grant Consortium, which makes space accessible to students.
  - RockSat-C features a competition for to get payloads aboard rockets, similar to what students would face as scientists in the field. The program actively engages the students through full design-process mentoring, assisting them through the design phase in the fall semester ... and leading the teams through testing and integration reviews and Launch Readiness Review in the spring.
  - The Orion rocket payload descended by parachute into the Atlantic Ocean off the coast of Wallops.
  - Suborbital rockets usually provide a few minutes of weightlessness at the peak of the flight, allowing for brief experiments in microgravity to go forward.
  - Another option for going high in the atmosphere is via high-altitude balloon.
  - NASA's next scheduled Wallops flight is a Black Brant IX suborbital sounding rocket, for July 7. ##
- This issue is online at: [www.moonsociety.org/international/ttsiq/](http://www.moonsociety.org/international/ttsiq/) and at: [www.nss.org/tothestars/miwcepts](http://www.nss.org/tothestars/miwcepts)



## List of Recent Feature Articles and Essays in Our Sister Publications



Ad Astra [Latin (ancient Roman): "To The Stars"]

Sent to all National Space Society Members as a primary membership benefit  
(with choice of print hardcopy or downloadable pdf file)

### SUMMER 2015 issue

- 12 BEYOND MARS: Travels in the Outer Solar System – Michael Carrol
- 18 STRETCHING THE BOUNDARIES: Getting in Shape for Space Over the Next 10 Years – John F. Cross
- 22 COMMON GROUND: Asteroid Mining and Planetary Defense – James G. Howe
- 26 ASTEROID MINING FOR SPACE TRAVEL – Dave Dietzler
- 30 THE FLEDGLING DRAGON: China's Human Space Program – Clifford R. McMurray
- 34 SMALLSAT REVOLUTION – Mark Williamson
- 42 TO BE OR NOT TO BE?: Mankind's Exodus to the Stars – Nelson Bridwell
- 44 Why an International Lunar Decade Campaign for Science, Exploration and Development Can Make a Difference – Dave Dunlop and Fred Becker



[www.MMM-MoonMinersManifesto.com](http://www.MMM-MoonMinersManifesto.com)

### MAY 2015 – MMM #285

- 2. **In Focus:** The Moon and Private Enterprise: "toes in the water" – Peter Kokh
- 3. Teleoperated "Enterprises" Feasible on the Moon – no crew support – or "Making Money on the Moon without Anyone Going There" – Peter Kokh
- 7. Telescopes on the Moon: Professional and Amateur alike. – Peter Kokh
- 8. Two moonlets, Phobos & Deimos, may be Mars' Export Trump Card – Dave Dietzler and Peter Kokh

### JUNE 2015 – MMM #286

- 3 For the Dawn Probe: Beyond Ceres: A swing by Pallas? – Peter Kokh
- 4 "Reimagineering" Public Images of Moon & Mars Bases & Outposts – Peter Kokh
- 5. Ways to make Moon & Mars Settlement Easier & Less Expensive – Peter Kokh
- 6. The Moon & Mars are so boringly "monochromatic" – Opticians to the Rescue – Peter Kokh
- 7. Living in the Moon's "Outback" – its "Farside" – Peter Kokh
- 8. Musings About Mars' Moonlets: Phobos and Deimos – Dave Dietzler

As usual, there is no July issue

## Moon Miners' Manifesto Resources

<http://www.moonsociety.org/chapters/milwaukee/mmm/>

MMM is published 10 times a year (except January and July. The December 2011 issue began its 26<sup>th</sup> year of continuous publication.

Most issues deal with the **opening of the Lunar frontier**, suggesting how pioneers can make best use of **local resources** and learn to **make themselves at home**. This will involve psychological, social, and physiological adjustment.

Some of the points made will relate specifically to **pioneer life** in the lunar environment. But much of what will hold for the Moon, will also hold true for **Mars and for space in general**. We have one Mars theme issue each year, and occasionally **other space destinations** are discussed: the asteroids, Europa (Jupiter), Titan (Saturn), even the cloud tops of Venus.

Issues #145 (May 2001) forward through current are as pdf file downloads with a Moon Society username and password. Moon Society International memberships are \$35 US; \$20 students, seniors – join online at:

<http://www.moonsociety.org/register/>

**MMM Classics:** All the “non-time-sensitive editorials and articles from past issues of MMM have been re-edited and republished in pdf files, one per publication year. A 3-year plus lag is kept between the MMM Classic volumes and the current issue. **As of December 2011, the first twenty-two years of MMM, 200 issues, will be preserved in this directory**, These issues are freely accessible to all, no username or password needed, at:

[www.moonsociety.org/publications/mmm\\_classics/](http://www.moonsociety.org/publications/mmm_classics/)

**MMM Classic Theme Issues:** introduced a new series to collect the same material as in the Classics, but this time organized by theme. The first MMM Classic Theme issue gathers all the **Mars** theme articles from years 1–10 in one pdf file. A second pdf file collects all the Mars Theme issues from year 11–20. The 2<sup>nd</sup> Classic Theme is “**Eden on Luna**,” addressing environmental issues underlying lunar settlement. **Asteroids, Tourism, Research, Select Editorials, and Analog Programs** have been added. New Theme Issues will be coming: Lunar Building Materials, The Lunar Economy, The Lunar Homestead, Modular Architecture, Modular Biospherics, Frontier Arts & Crafts, Frontier Sports, Other Solar System Destinations, and so on.

[www.moonsociety.org/publications/mmm\\_themes/](http://www.moonsociety.org/publications/mmm_themes/)

**MMM Glossary:** The publishers of MMM, the Lunar Reclamation Society, has published a new Glossary of “MMM-Speak: new words and old words with new meaning” as used in Moon Miners' Manifesto.

[www.moonsociety.org/publications/m3glossary.html](http://www.moonsociety.org/publications/m3glossary.html)

The initial addition includes over 300 entries, many with illustrations. Additional entries are under construction. It is hoped that new members will consider this to be a “Read Me First” guide, not just to Moon Miners' Manifesto, but to our vision and goals.

**All of these resources are available online or as free access downloads to readers.  
But TTSIQ does need your help!**

### To The Stars International Quarterly Advisors, Liaisons, Contributors, Reporters, Illustrators

If this publication is to help spread the word about Space worldwide, among the public at large, especially among the students and younger people, it must become a truly International publication. We need people from many fields to join our team.

If you think you can add to the usefulness and vitality of this publication, in any way listed above, or in fields we had not thought of, write us at: [ttsiq@moonsociety.org](mailto:ttsiq@moonsociety.org) [This email address goes to the editorial team]

Tell us about yourself; your interest in space, and how you think you can make this publication of real service in the education of the public and of young people on whom the future of the world rests.

**Guidelines for Submissions** TTSIQ is intended for wide public distribution to encourage support for space research and exploration and development. TTSIQ is not a scholarly review or a technical journal for professional distribution. Submissions should be short, no more than a few thousand words. Longer pieces may be serialized editorials and commentary, reports on actual developments and proposals, glimpses of life on the future space frontier, etc. Articles about launch vehicles and facilities, space destinations as Earth Orbit, The Moon, Mars, the asteroids, and beyond, challenges such as dealing with moon dust, radiation, reduced gravity, and more.

### Help Circulate To The Stars International Quarterly

If you know someone who might enjoy reading this publication, send us their email address(es) so that they receive notice when a new issue is published. Readers are encouraged to share and to distribute these issues widely, either as email attachments, or via the direct download address (for all issues)

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## The Stars International Quarterly #12

Engage! And Enjoy!