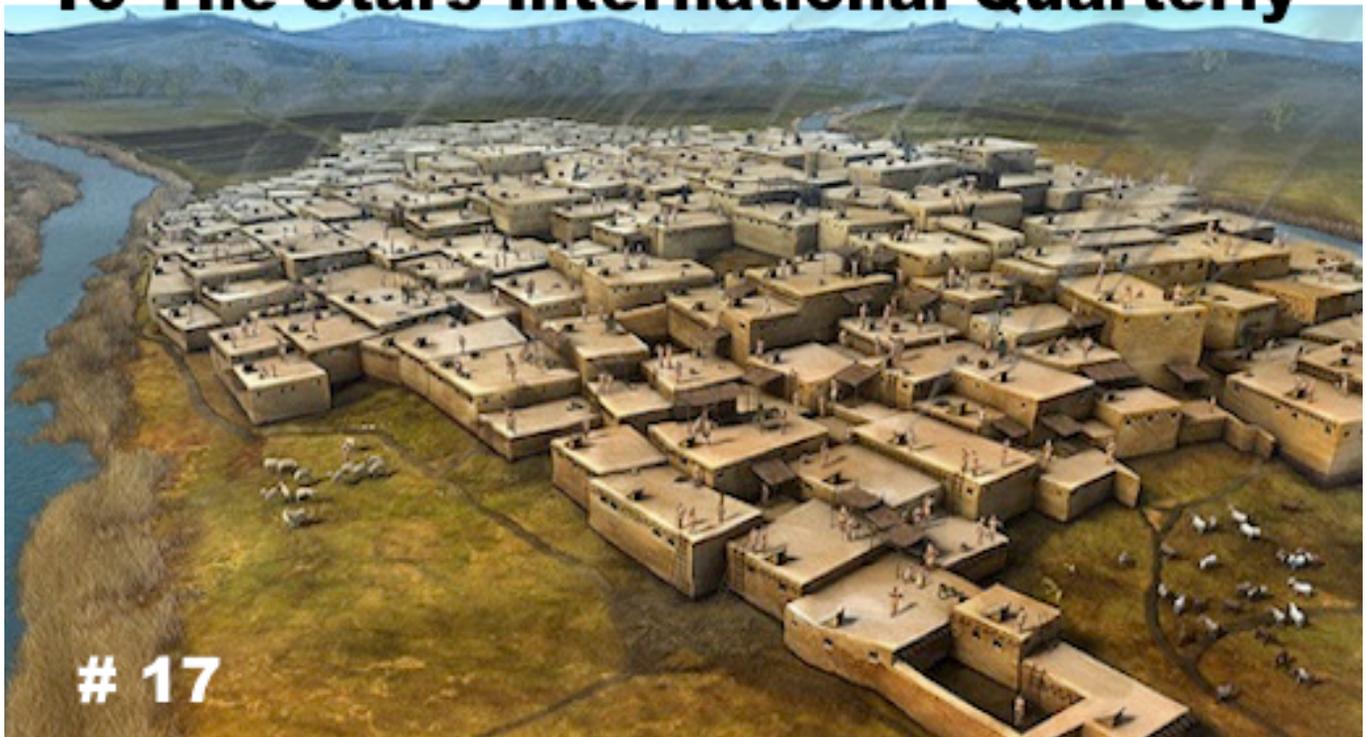


# To The Stars International Quarterly



A reconstruction of Catal Huyuk, in southern Turkey, the 1st know city on Earth.  
What will the first cities on the Moon and Mars look like?

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**Outbound** will replace both **Moon Miners’ Maniesto** and **To The Stars International Quarterly**  
After MMM #301 December 2016 and TTTSIQ # 18. See last page.

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

## 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.



## Keeping up with the Space News – How we do it

Peter Kokh, Editor, [kokhmmm@aol.com](mailto:kokhmmm@aol.com)

A feature of this publication from the outset has been **Space News Browsing Links**; Putting this news section together requires checking the news daily. To do this I rely on a variety of sources, but I started with just one. Some years back, the Moon Society had arranged for the current daily “space news” (guided by a number of key words which the society had supplied) from a free web search service. The Moon Society hosts a site updated several times a day:

- <http://legacy.moonsociety.org/zebrafeeds/demo.php> (new address)

I have also found a number of other sources, **most of them updated weekly**

- [www.space.com](http://www.space.com) --- <http://www.moondaily.com> --- <http://www.marsdaily.com>
- <http://www.saturndaily.com> --- <http://www.terradaily.com> --- <http://www.spacedaily.com>
- <http://www.skynightly.com> --- <http://www.gpsdaily.com> --- <http://www.solardaily.com>

It is not uncommon for the same story to be listed on more than one of the above sites.

The latest addition to my source list, updated weekly, includes news the sites above may miss.

- <http://phys.org/space-news/> – articles on this site, when they cover a story found on one or more of the sites above, tend to be a bit more complete and professional. More importantly, this site commonly lists one or more relevant space news items missed by the other sites.

I cover these news items, with an image if any and a brief summary, in TTSIQ. ##

The address on the Moon Society site of stored TTSIQ issues, has also changed:

Old address: <http://www.moonsociety.org/international/ttsiq/>

New address: <http://legacy.moonsociety.org/international/ttsiq/> --- Editor



## SPACE AGENCIES

### China's first commercial space center to be built in Wuhan, China

[www.spacedaily.com/reports/First\\_commercial\\_space\\_base\\_to\\_be\\_built\\_in\\_Wuhan\\_999.html](http://www.spacedaily.com/reports/First_commercial_space_base_to_be_built_in_Wuhan_999.html)

September 14, 2016 – China's first commercial space industry center will be built in Wuhan, capital of Hubei province. The Wuhan National Space Industry Base will focus on the development of carrier rockets and satellites, commercial launch services and applications of satellite data. The base plans to establish an annual production capacity of 50 carrier rockets and 140 commercial satellites by 2020. ##

## ROCKET TECHNOLOGIES

### Amazon's chief Jeff Bezos unveils new rocket design

<http://phys.org/news/2016-09-amazon-chief-jeff-bezos-unveils.html>

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

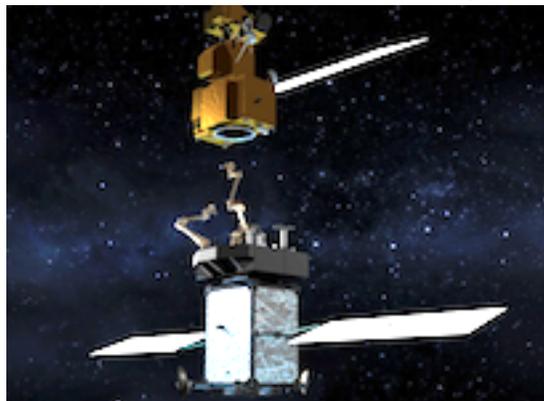
**September 12, 2016** – Amazon founder Jeff Bezos unveiled plans Monday for a massive rocket called New Glenn designed to launch people to space and propel satellites into orbit, raising the ante in the US commercial space industry.



The rocket has been in the works for the past four years, and will be launched by decade's end. At 270 feet (82 meters) high for the two-stage "New Glenn" and 313 feet tall for the three-stage version, the rocket will be taller than any on the market today, including SpaceX's Falcon 9 (224 feet).

## Robotic Satellite Servicing Tech Ready for Orbital Tests?

[www.space.com/34183-robotic-satellite-servicing-a-reality-soon.html](http://www.space.com/34183-robotic-satellite-servicing-a-reality-soon.html)



Robotic satellite servicing spacecraft, like NASA's planned Restore-L vehicle scheduled to refuel the Landsat 7 satellite in 2020, can extend the mission life of satellites in orbit today.

Technologies that would service and refuel satellites in orbit are finally ready to move forward after years of technical, regulatory and financial challenges, industry experts said at the AIAA Space conference, held earlier this month. "Technologies that would service and refuel satellites in orbit are finally ready to move forward after years of technical, regulatory and financial challenges," industry experts said at the AIAA Space conference, held earlier this month.

Those missing elements are coming soon and that, when they arrive, there's going to be a "paradigm change." Currently, satellites are abandoned in orbit when they suffer a mechanical failure or run out of fuel. Using vehicles that service satellites in orbit would add years of life to those spacecraft by refueling, repairing, upgrading and relocating them.

One step NASA is taking toward satellite-servicing capabilities is its **Raven** system, which will be attached to the International Space Station (ISS) to track crew and cargo vehicles as they arrive at and depart from the station. The data Raven collects will be used to **demonstrate real-time navigation sensors and algorithms** that will be incorporated into future servicing spacecraft and missions.

NASA's Restore-L is one of those future servicing missions. The spacecraft, set to launch in 2020, will refuel the aging Landsat 7 remote sensing satellite that was launched back in 1999,##

## Dream Chaser Space Plane to Fly United Nations Mission in 2021

[www.space.com/34218-dream-chaser-united-nations-space-plane-mission.htm](http://www.space.com/34218-dream-chaser-united-nations-space-plane-mission.htm)

[www.space.com/19552-dream-chaser.html](http://www.space.com/19552-dream-chaser.html)

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

September 28, 2016 – A private space plane is set to fly the United Nations' first-ever space mission five years from now. Sierra Nevada Corporation (SNC) and the United Nations Office for Outer Space Affairs (UNOOSA) are teaming up to launch a two-week robotic mission to low-Earth orbit in 2021 using the company's Dream Chaser spacecraft.



The spacecraft, **originally developed by a company called SpaceDev**, is among a group of ships that vied for private flights to the International Space Station. NASA funded SpaceX's and Boeing's concepts in 2014 for the last round of Commercial Crew Program development, sparking a formal protest from Sierra Nevada. In 2016,

However, NASA selected Sierra Nevada, SpaceX and Orbital ATK for anticipated cargo missions to fly **between 2019 and 2024**. No specific flight awards have been made yet. ##

**Editor:** The SpaceDev project, led by **Jim Benson**, was launched in 1987, long before NASA's call for commercial vehicles to replace the Space Shuttle in servicing the International Space Station. Benson was given an award for the project at the 1989 International Space Development Conference in Milwaukee, WI. But after Benson's untimely death, the project was taken over by Sierra Nevada. We here in Milwaukee are delighted to see his dream move towards realization. ##

## Making space rocket fuel from water could drive a power revolution on Earth

<http://phys.org/news/2016-09-space-rocket-fuel-power-revolution.html>

September 28, 2016 – Researchers led by NASA's former chief technologist are hoping to launch a satellite carrying **water as the source of fuel**. The Cornell University team want their device to become **the first shoebox-sized "CubeSat" to orbit the Moon**, while demonstrating **the potential of water as a source of spacecraft fuel**. It's a safe, stable substance that's relatively common even in space, but could also find greater use here on Earth as we search for alternatives to fossil fuels..

Water is a way around this issue because it is essentially an energy carrier rather than a fuel. The Cornell team isn't planning to use water itself as a propellant but to rather **use electricity from solar panels to split the water into hydrogen and oxygen and use them as the fuel**. The two gasses, when recombined and ignited will burn or explode, giving out the energy that they took in during the splitting process. This combustion of gasses can be used to drive the satellite forward, gaining speed or altering its position in orbit of whichever desired planet or moon is the target. ##

## ASTRONAUTS

### Study shows heart hazard for Apollo astronauts

July 28, 2016 – [www.space-travel.com/reports/Heart\\_hazard\\_for\\_Apollo\\_astronauts\\_study\\_999.html](http://www.space-travel.com/reports/Heart_hazard_for_Apollo_astronauts_study_999.html)

NASA's Apollo astronauts, the only humans to have travelled beyond Earth's protective magnetosphere, die disproportionately of heart and blood vessel diseases, researchers said Thursday, blaming radiation. This raises health concerns for all humans with dreams of traveling to the Moon, Mars or beyond, as we vie to expand humankind's extraterrestrial footprint. ##

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

## Mitigating health risks of long duration spaceflight

[www.spacedaily.com/reports/Researchers\\_Measure\\_Monitor\\_and\\_Mitigate\\_Potential\\_Health\\_Risks\\_of\\_Long\\_Duration\\_Spaceflight\\_999.html](http://www.spacedaily.com/reports/Researchers_Measure_Monitor_and_Mitigate_Potential_Health_Risks_of_Long_Duration_Spaceflight_999.html)

July 29, 2016 – Biomedical research that aims to prevent heart disease is an important part of the NASA Human Research Program. One example is the Cardio Ox study, which uses the unique microgravity environment of the International Space Station to understand changes to the cardiovascular system in astronauts living and working in low-Earth orbit.

Radiation is another top health concern for astronauts. Crew members who travel beyond low-Earth orbit will be exposed to more and different types of radiation because they will not be protected by Earth's magnetosphere. ##

## ROBOTICS

### Team of robots learns to work together, without colliding

[www.spacedaily.com/reports/Team\\_of\\_robots\\_learns\\_to\\_work\\_together\\_without\\_colliding\\_999.html](http://www.spacedaily.com/reports/Team_of_robots_learns_to_work_together_without_colliding_999.html)

September 14, 2016 – When roboticist create behaviors for teams of robots, they first build algorithms that focus on the intended task. Then they wrap safety behaviors around those primary algorithms to keep the machines from running into each other.

Each robot is essentially given an invisible bubble that other robots must stay away from. As long as nothing touches the bubble, the robots move around without any issues. But that's where the problems begin. ##

### One-eyed Robot learns to see in Weightlessness

[www.esa.int/Our\\_Activities/Space\\_Engineering\\_Technology/One-eyed\\_robot\\_learns\\_to\\_see\\_in\\_weightlessness/](http://www.esa.int/Our_Activities/Space_Engineering_Technology/One-eyed_robot_learns_to_see_in_weightlessness/)



September 28, 2016 = A small European Space Agency drone taught itself to judge distances using only one eye during trials aboard the International Space Station, Although humans can effortlessly estimate distances with a single eye, robots still lack this capability.

It is a mathematical impossibility to extract distances to objects from one single image, if the object has not been encountered before. But if we recognize something to be a car, then we know its physical characteristics, and we can use that information to estimate its distance from us. A similar logic is what ESA wanted the drone to learn during our experiment.

One of the Spheres – Synchronized Position Hold Engage and Reorient Experimental Satellite – drones resident in the Space Station was pressed into service for testing. With 12 carbon dioxide gas thrusters enabling rotation and movement in all direction, the bowling ball-sized Spheres are essentially free-floating mini-spacecraft within the Station, used for testing a wide variety of technology.

For this test, a drone began navigating inside Japan's module while recording stereo vision information from its two camera 'eyes'. It then began to learn about the distances to walls and nearby obstacles so that when its stereo camera was switched off, it could then begin autonomous exploration using only a single camera. ##

**SPACE STATION NEWS.****World's first virtual reality camera satellite to be launched into space**

[www.spacedaily.com/reports/Worlds\\_first\\_virtual\\_reality\\_camera\\_satellite\\_to\\_be\\_launched\\_into\\_space\\_999.html](http://www.spacedaily.com/reports/Worlds_first_virtual_reality_camera_satellite_to_be_launched_into_space_999.html)



August 10, 2016 – SpaceVR, a platform for creating cinematic, live, virtual space tourism, reports it has signed a launch agreement with NanoRacks LLC to send Overview 1, the world's first virtual reality camera satellite, into space. Overview 1 will be delivered to the International Space Station aboard the SpaceX CRS-12 Mission. The satellite will then be deployed into Low Earth Orbit from the NanoRacks CubeSat Deployer (NRCSD).

SpaceVR aims to give everyone the opportunity to experience the truly infinite, boundless Universe through virtual reality. Its debut satellite, Overview 1, will use 4K sensors to capture extremely high resolution, fully immersive, 360-degree video of every breathtaking moment that occurs on our home planet. The content will be viewable on any virtual reality device, ranging from smartphones to Oculus Rift to extreme resolution devices such as the StarVR. ##

**'New port of call' installed at space station**

August 19, 2016 – <http://phys.org/news/2016-08-port-space-station.html>

With more private spaceship traffic expected at the International Space Station in the coming years, two spacewalking US astronauts installed a special parking spot for them. Americans Jeff Williams and Kate Rubins floated outside the orbiting laboratory for a spacewalk lasting 6 hours to attach the first of two international docking adaptors. During the rest of the spacewalk, astronauts connected power and data cables for the adaptor. The fittings will enable the space station to share power and data with visiting spaceships. ##

**China launches second space station, Tiangong 2**

<http://phys.org/news/2016-09-china-space-station-tiangong.html>



September 15, 2016 – The Tiangong 2 was carried into space on Thursday night atop a Long March 7 rocket from the Jiuquan Satellite Launch Center on the edge of the Gobi Desert in northern China.

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

Plans call for the launch next month of the Shenzhou 11 spaceship with two astronauts to dock with the station and remain on board for a month. The station, whose name means "Heavenly Palace," is considered a stepping stone to a mission to Mars by the end of the decade.

The Tiangong 2 module will be used for "testing systems and processes for mid-term space stays and refueling," and will house experiments in medicine and various space-related technologies. ##

## China eyes year-long stays for space station astronauts

[www.spacedaily.com/reports/China\\_eyes\\_year-long\\_stays\\_for\\_space\\_station\\_astronauts\\_999.html](http://www.spacedaily.com/reports/China_eyes_year-long_stays_for_space_station_astronauts_999.html)

September 16, 2016 – China could send astronauts to its space station for more than a year at a time once it goes operational in 2022. The country's second space lab, the Tiangong-2 -- or Heavenly Palace-2 -- is expected to operate for at least two years.

Construction on a space station will start in as early as 2017 and take around three years, before it enters into service in 2022. Astronauts could be stationed in orbit for missions that last for more than one year in the facility, which has an initial designed life of at least 10 years.

The Chinese space station will weigh over 60 tonnes -- much smaller than the 420-tonne International Space Station -- and consist of a core module attached to two space labs. It will normally accommodate three astronauts at a time but will have a maximum capacity of six. ##

## Tiangong 2 initial tests proceeding well

[www.spacedaily.com/reports/Tiangong\\_2\\_initial\\_tests\\_proceeding\\_well\\_999.html](http://www.spacedaily.com/reports/Tiangong_2_initial_tests_proceeding_well_999.html)

September 22, 2016 – Several days after its launch, China's Tiangong 2 space laboratory seems to be working well. The uncrewed module has made engine burns and orbital changes, demonstrating its capabilities. China will launch the Shenzhou 11 spacecraft at some point in October, carrying two astronauts to live on board the laboratory. The crew will live on Tiangong 2 for around 30 days, ##

## Boeing And SpaceX Closer To Ferrying Astronauts To Space | Video

[www.space.com/34138-boeing-and-spacex-closer-to-ferrying-astronauts-to-space-video.html](http://www.space.com/34138-boeing-and-spacex-closer-to-ferrying-astronauts-to-space-video.html)

September 21, 2016 – NASA's Commercial Crew Program is making strides in getting astronauts to Space from American soil once again. Boeing's Starliner and SpaceX's Dragon capsules are under development, along with necessary upgrades to the Space Station for them.

## ORBITAL SPACE DEBRIS PROBLEM

### US, China Will Meet This Year to Talk Space Debris

[www.space.com/34170-us-china-will-meet-this-year-to-talk-space-debris.html](http://www.space.com/34170-us-china-will-meet-this-year-to-talk-space-debris.html)



Artist's

Impression

MAUI, Hawaii – China and the United States plan to hold a second set of talks later this year to discuss how their militaries operate in space. The two sides met for a separate discussion of military space topics for the first time in May. On Jan. 11, 2007, China deliberately destroyed one of its defunct weather satellites, Fengyun-1C using a ground-based, medium-range ballistic missile. The action, which was widely condemned throughout the international space community, left a cloud of potentially hazardous debris in a heavily used belt of Earth orbit. ##

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## MISSION TO PLANET EARTH

**Massive 'Lava Lamp' Blobs Deep Inside Earth Have Scientists Puzzled**

July 6, 2016 – [www.yahoo.com/news/massive-lava-lamp-blobs-deep-inside-earth-scientists-133739047.html](http://www.yahoo.com/news/massive-lava-lamp-blobs-deep-inside-earth-scientists-133739047.html)

Two continent-size blobs of hot — and possibly molten — rock can be found deep underground, about halfway to the center of the Earth, according to a new study. These curious structures — each of which is so large that it would be 100 times taller than Mount Everest — could be made up of materials that may shed light on how the Earth formed, ##

**Did Supernova Explosion Contribute to Earth Mass Extinction?**

July 11, 2016 – [www.space.com/33379-supernova-explosions-earth-life-mass-extinction.html](http://www.space.com/33379-supernova-explosions-earth-life-mass-extinction.html)

A faraway supernova explosion may have contributed to a minor mass extinction here on Earth 2.59 million years ago, a new study suggests.

Fast-moving, charged particles called cosmic rays that were blasted out by a supernova may have played a role in the climatic changes that apparently led to a die-off at the end of the Pliocene epoch and the start of the Pleistocene.

"Africa dried out, and a lot of the forest turned into savannah. Around this time and afterwards, we started having glaciations — ice ages — over and over again, and it's not clear why that started to happen. ##

**(Follow up) Supernova Ashes Found in Fossils Hint at Extinction Event**

August 18, 2016 – [www.space.com/33777-supernova-ash-found-in-fossils.html](http://www.space.com/33777-supernova-ash-found-in-fossils.html)

Tiny magnetofossils in sediments from the Pacific Ocean floor have been found to contain iron-60, a type of iron produced in a supernova explosion that signals the death of a star. Because the fossils contain a variety of iron that is most likely the product of a supernova event that occurred light-years from Earth, this finding also suggests that the event might have played a role in an extinction event on Earth. Previous research has found that supernovas generate a mildly radioactive variety of iron known as iron-60. These cataclysmic explosions then hurl vast amounts of iron-60 — more than five to 10 times the mass of the Sun — out into space. Iron-60 that's produced in other natural ways creates only up to a tenth as much. Iron-60 found on Earth and on the Moon likely is ash from supernovas.

Now scientists have discovered iron-60 within fossilized chains of magnetic crystals of a mineral known as magnetite. These "magnetofossils," each of which is about 90 nanometers — or billionths of a meter — large, were created by microbes known as magnetotactic bacteria – **a supernova at least 325 light-years from Earth** blasted the planet with iron ash about 2 million years ago. ##

**CryoSat sets new standard for measuring sea levels**

[www.spacedaily.com/reports/CryoSat\\_sets\\_new\\_standard\\_for\\_measuring\\_sea\\_levels\\_999.html](http://www.spacedaily.com/reports/CryoSat_sets_new_standard_for_measuring_sea_levels_999.html)

July 28, 2016 – Trying to measure sea levels around rugged coastlines is not always an easy task. ESA's CryoSat satellite is making a difference with its radar altimeter. Sea level is a very sensitive indicator of climate change, reflecting components of the climate system such as heat, glaciers and the melting of ice-sheets.

Precisely monitoring changes in the average level of oceans is vitally important for understanding not only climate but also the social and economic consequences of any rise in sea level, especially in coastal zones. ##

**Collecting Fingerprints in the Sky**

August 2, 2016 = [www.spacedaily.com/reports/Collecting\\_Fingerprints\\_in\\_the\\_Sky\\_999.html](http://www.spacedaily.com/reports/Collecting_Fingerprints_in_the_Sky_999.html)

**ACT-America**, the Atmospheric Carbon and Transport – America expedition, is studying the movement of two powerful greenhouse gases – **carbon dioxide and methane. Plants take up lighter carbon, and emitted carbon has a different ratio.** Gases have certain tracers, such as SF6 used in electrical transformers, and those tracers stay with them as they rise into the atmosphere as a plume. We're basically getting a fingerprint on where the plumes are coming from. ##

## Accounting for Ozone

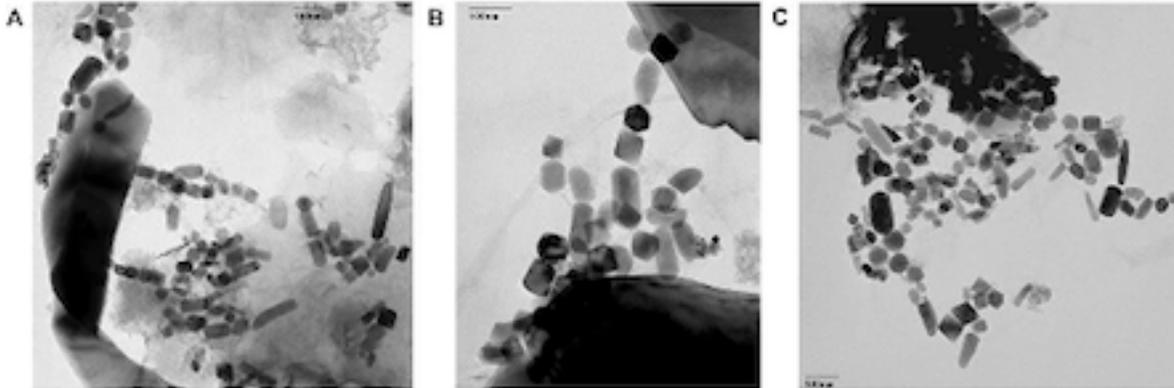
August 10, 2016 – [www.spacedaily.com/reports/Accounting\\_for\\_ozone\\_999.html](http://www.spacedaily.com/reports/Accounting_for_ozone_999.html)

The first peer-reviewed study to directly quantify how emissions from oil and gas activities influence summertime ozone pollution in the Colorado Front Range confirms that chemical vapors from oil and gas activities are a significant contributor to the region's chronic ozone problem. ##

## Supernova Ashes Found in Fossils Hint at Extinction Event

[www.space.com/33777-supernova-ash-found-in-fossils.html](http://www.space.com/33777-supernova-ash-found-in-fossils.html)

August 18, 2016 – Supernova ash has been discovered in fossils that were created by bacteria on Earth, a new study finds. Because the fossils contain a variety of iron that is most likely the product of a supernova event that occurred light-years from Earth, this finding also suggests that the event might have played a role in an extinction event on Earth,



Tiny magnetofossils in sediments from the Pacific Ocean floor have been found to contain iron-60, a type of iron produced in a supernova explosion that signals the death of a star.

## Recent connection between North and South America reaffirmed

[www.spacedaily.com/reports/Recent\\_connection\\_between\\_North\\_and\\_South\\_America\\_reaffirmed\\_999.html](http://www.spacedaily.com/reports/Recent_connection_between_North_and_South_America_reaffirmed_999.html)

August 19, 2016 – Long ago, one great ocean flowed between North and South America. When the narrow Isthmus of Panama joined the continents about 3 million years ago, it also separated the Atlantic from the Pacific Ocean. If this took place millions of years earlier, as recently asserted by some, the implications for both land and sea life would be revolutionary. ##

## Giant Cruise Ship heads to Arctic on pioneering journey

[www.spacedaily.com/reports/Giant\\_cruise\\_ship\\_heads\\_to\\_Arctic\\_on\\_pioneering\\_journey\\_999.html](http://www.spacedaily.com/reports/Giant_cruise_ship_heads_to_Arctic_on_pioneering_journey_999.html)



The Crystal Serenity set off from Seward, Alaska on August 16 with nearly 1,000 passengers, and is scheduled to dock in New York on September 17.

August 24, 2016 – Thanks to climate change, a luxury cruise ship, the Crystal Serenity, has undertaken a pioneering journey that will see it sail through the once impassable Northwest Passage during a month-long trip that is drawing much excitement but also criticism from environmentalists.

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

The voyage marks the first time a passenger ship this size sails the storied Northwest Passage where warmer temperatures and melting ice are opening the Arctic -- one of the most pristine places on Earth -- for business. Passengers on board the \$350 million vessel paid between \$22,000 and \$120,000 for the journey, which took three years of planning and preparation to avoid any mishaps, including a repeat of the Titanic. Guests were also required to purchase \$50,000 in emergency evacuation insurance in order to cruise through the Northwest Passage -- a once unnavigable shortcut between the Atlantic and Pacific oceans that is increasingly becoming a popular route for shipping.

There has been much criticism of the venture. ##

### Researchers find Earth composed of different materials than primitive meteorites

<http://phys.org/news/2016-09-earth-materials-primitive-meteorites.html>

<http://phys.org/news/2016-09-discovery-shatters-previous-beliefs-earth.html>

September 15, 2016 – Scientists from Lawrence Livermore National Laboratory (LLNL) have found that, contrary to popular belief, the Earth is not comprised of the same material found in primitive meteorites (also known as chondrites). This is based on the determination that the abundance of several neodymium (Nd) isotopes are different in the Earth and in chondritic meteorites. **A long-standing theory assumes that the chemical and isotopic composition of most elements in the bulk silicate Earth is the same as primitive meteorites.**

However, 10 years ago it was discovered that rocks on the surface of the Earth had a higher abundance of  $^{142}\text{Nd}$  than primitive meteorites, leading to a hypothesis that Earth had either a hidden reservoir of Nd in its mantle or inherited more of the parent isotope  $^{146}\text{Sm}$  (Sm), which subsequently decayed to  $^{142}\text{Nd}$ . ##

### In eastern Tibetan forest, signs of tree growth amid climate change

[www.terraviva.com/reports/In\\_eastern\\_Tibetan\\_forest\\_signs\\_of\\_tree\\_growth\\_amid\\_climate\\_change\\_999.html](http://www.terraviva.com/reports/In_eastern_Tibetan_forest_signs_of_tree_growth_amid_climate_change_999.html)

September 13, 2016 – Word of mouth from nomadic herders led Lucas Silva into Tibetan forests and grasslands. What his team found was startling: Rapid forest growth in tune with what scientists had been expecting from climatic changes triggered by rising levels of carbon dioxide. ##

### Earth's Atmospheric Oxygen Levels Continue Long Slide

[www.space.com/34163-earth-atmospheric-oxygen-levels-declining.html](http://www.space.com/34163-earth-atmospheric-oxygen-levels-declining.html)

September 22, 2016 – Atmospheric oxygen levels have declined over the past 1 million years, although not nearly enough to trigger any major problems for life on Earth.



Researchers analyzed samples from ice core drilling stations in **Antarctica and Greenland** to evaluate the planet's **atmospheric oxygen levels throughout history.**

The research behind this new finding could help shed light on what controls **atmospheric oxygen levels** over long spans of time. Atmospheric oxygen levels are fundamentally linked to the evolution of life on Earth, as well as changes in geochemical cycles related to climate variations. As such, scientists have long sought to reconstruct how atmospheric oxygen levels fluctuated in the past and what might control these shifts.##

## Making space rocket fuel from water could drive a power revolution on Earth

<http://phys.org/news/2016-09-space-rocket-fuel-power-revolution.html>

September 28, 2016 – Researchers led by NASA's former chief technologist are hoping to launch a satellite carrying **water as the source of fuel**. The Cornell University team want their device to become **the first shoebox-sized "CubeSat" to orbit the Moon**, while demonstrating **the potential of water as a source of spacecraft fuel**. It's a safe, stable substance that's relatively common even in space, but could also find greater use here on Earth as we search for alternatives to fossil fuels..

Water is a way around this issue because it is essentially an energy carrier rather than a fuel. The Cornell team isn't planning to use water itself as a propellant but to rather **use electricity from solar panels to split the water into hydrogen and oxygen and use them as the fuel**. The two gasses, when recombined and ignited will burn or explode, giving out the energy that they took in during the splitting process. This combustion of gasses can be used to drive the satellite forward, gaining speed or altering its position in orbit of whichever desired planet or moon is the target. ##



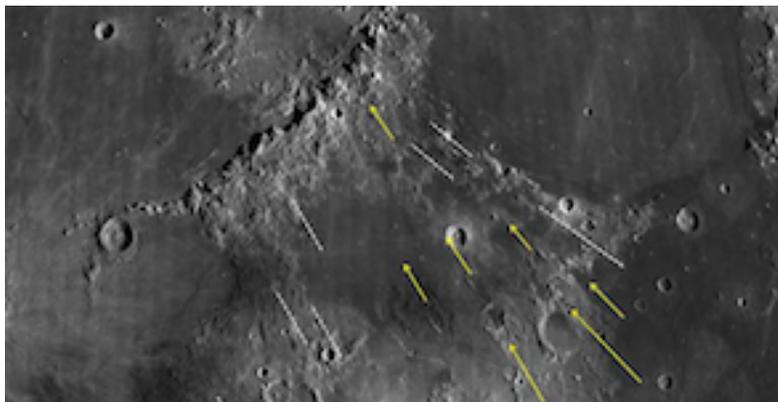
### THE MOON

We insist on capitalizing "Moon" when it refers to Earth's satellite. Read why:

<http://legacy.moonsociety.org/info/capital-M-for-Moon.html>

## Asteroid that formed Moon's Imbrium Basin may have been protoplanet-sized

<http://phys.org/news/2016-07-asteroid-moon-imbrium-basin-protoplanet-sized.html>



July 20, 2016 – Grooves and gashes associated with the Imbrium Basin on the Moon have long been puzzling. New research shows how some of these features were formed and uses them to estimate the size of the Imbrium impactor. The study suggests it was big. ##

### MOON – UNMANNED MISSIONS

## Taiwan to make lunar lander for NASA Moon-mining mission

[www.space-travel.com/reports/Taiwan\\_to\\_make\\_lunar\\_lander\\_for\\_NASA\\_moon-mining\\_mission\\_999.html](http://www.space-travel.com/reports/Taiwan_to_make_lunar_lander_for_NASA_moon-mining_mission_999.html)

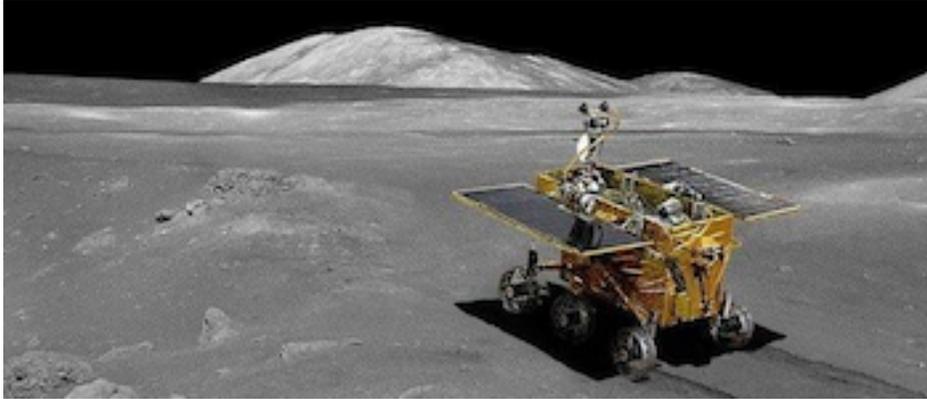
July 16, 2016 – Taiwan is building a \$47 million lunar lander as part of the first ever moon-mining project. The lander, to be made by the island's Chung-shan Institute of Science and Technology, will carry a rover and touch down on the moon's surface after a three-day journey from Earth.

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

US space agency NASA is leading the project, which is called **Resource Prospector** and aims to be the first mining expedition on another world. The rover is **designed to excavate hydrogen, oxygen and water** from the Moon, NASA says on its website. ##

### China's Jade Rabbit lunar rover dies in blaze of online glory

[www.space-travel.com/reports/Chinas\\_Jade\\_Rabbit\\_lunar\\_rover\\_dies\\_in\\_blaze\\_of\\_online\\_glory\\_999.html](http://www.space-travel.com/reports/Chinas_Jade_Rabbit_lunar_rover_dies_in_blaze_of_online_glory_999.html)

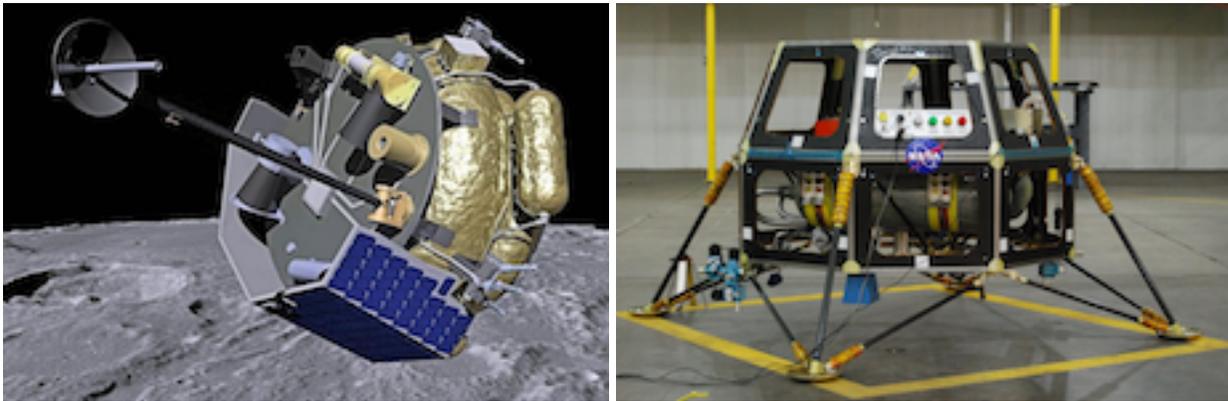


August 3, 2016 –China's troubled but beloved Jade Rabbit lunar rover has whirred its last. The device, designed for a lifespan of a mere three months, surveyed the Moon's surface for 31 months, overcoming numerous technical problems and design flaws to become a national icon. But it has stopped operations.

### Moon Express Approved for Private Lunar Landing in 2017, a Space First

August 3, 2016 = [www.space.com/33632-moon-express-private-lunar-landing-approval.html](http://www.space.com/33632-moon-express-private-lunar-landing-approval.html)  
[www.space-travel.com/reports/US\\_company\\_gets\\_historic\\_nod\\_to\\_send\\_lander\\_to\\_moon\\_999.html](http://www.space-travel.com/reports/US_company_gets_historic_nod_to_send_lander_to_moon_999.html)

“more than a milestone, a threshold for the entire commercial space industry



The U.S. government has officially approved the planned 2017 robotic lunar landing of Florida-based Moon Express, which aims to fly commercial missions to Earth's nearest neighbor and help exploit its resources. The new approval, while exclusive to Moon Express, could therefore serve as an important regulatory guide for deep space commercial activity in general. The interagency approval process "took some time, not because anybody was against or averse to this. It's just that we asked questions that had never been asked before, and that had to be addressed and worked out."

### China: “There is no water on the Moon”

[www.space-travel.com/reports/As\\_dry\\_as\\_the\\_moon\\_999.html](http://www.space-travel.com/reports/As_dry_as_the_moon_999.html)

August 4, 2016 – Data sent back to the Earth by Chinese lunar probe **Chang'e 3** has proved for the first time that there is no water on the moon. The lander has gathered data on the moisture content above the lunar surface and "got a figure so low that we have never seen before," said Wei Jianyan, a researcher of the National Astronomical Observatory at the Chinese Academy of Sciences.

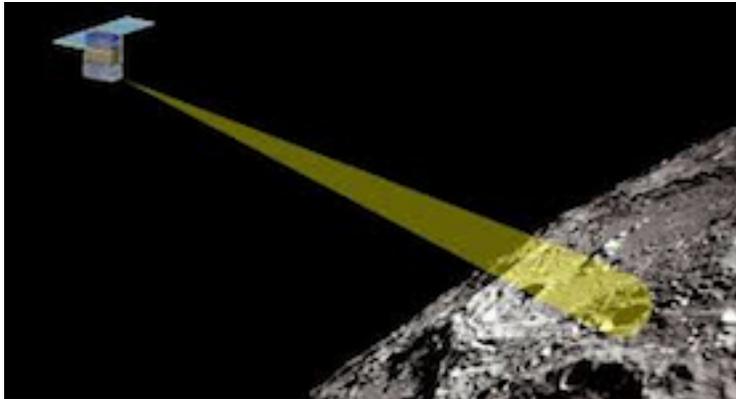
The result is in line with the expectations of experts. It's also the first time that mankind has proved there is no water on the Moon.

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

## Lockheed Martin, NASA Ink Deal for SkyFire Infrared Lunar Discovery Satellite

[www.space-travel.com/reports/Lockheed\\_Martin\\_NASA\\_Ink\\_Deal\\_for\\_SkyFire\\_Infrared\\_Lunar\\_Discovery\\_Satellite\\_999.html](http://www.space-travel.com/reports/Lockheed_Martin_NASA_Ink_Deal_for_SkyFire_Infrared_Lunar_Discovery_Satellite_999.html)

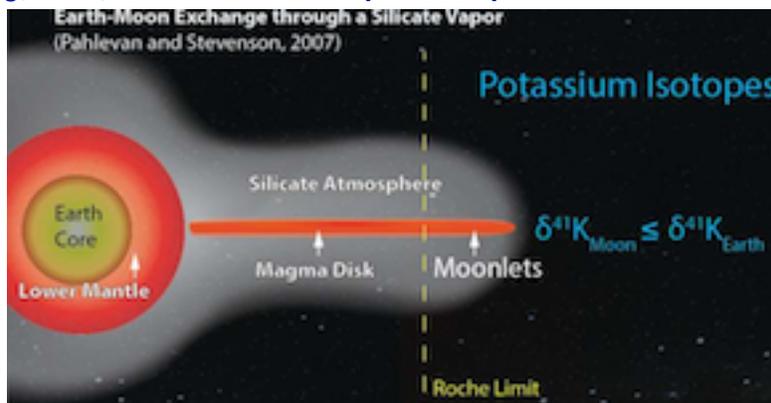
August 18, 2016 – SkyFire's lunar flyby will pioneer brand new infrared technology, enabling scientists to fill strategic gaps in lunar knowledge that have implications for future human space exploration.



The **SkyFire 6U CubeSat** is a small, lightweight imaging satellite, is set to be deployed in 2018 along with 12 other CubeSats on the Orion Exploration Mission-1. **The Moon will be only a "proving ground"** for possible future SkyFire missions. If successful, the infrared system on SkyFire could eventually be used for cost-effective studies of a planet's resources before humans arrive, ##

## Chemistry says Moon is proto-Earth's mantle, relocated

<http://phys.org/news/2016-09-chemistry-moon-proto-earth-mantle-relocated.html>



<http://cdn.phys.org/newman/csz/news/800/2016/chemistrysay.jpg>

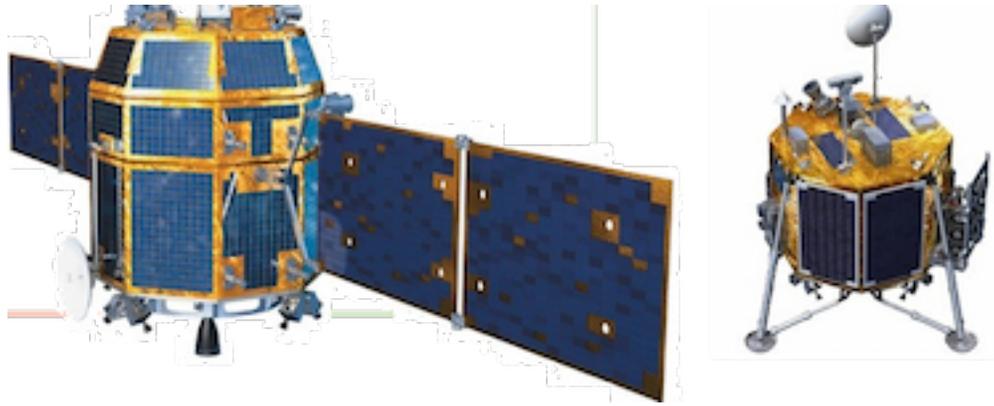
September 12, 2016 – Measurements of an element in Earth and Moon rocks have just disproved the leading hypotheses for the origin of the Moon. **Tiny differences in the segregation of the isotopes of potassium between the Moon and Earth were hidden below the detection limits of analytical techniques until recently.** But in 2015, Washington University in St. Louis geochemist Kun Wang, then the Harvard Origins of Life Initiative Prize postdoctoral fellow, and Stein Jacobsen, professor of geochemistry at Harvard University, developed a technique for analyzing these isotopes that can hit precisions 10 times better than the best previous method .

Wang and Jacobsen now report isotopic differences between lunar and terrestrial rocks that provide the first experimental evidence that can discriminate between the two leading models for the Moon's origin.

In one model, a low-energy impact leaves the proto-Earth and Moon shrouded in a silicate atmosphere; in the other, a much more violent impact vaporizes the impactor and most of the proto-Earth, expanding to form an enormous superfluid disk out of which the Moon eventually crystallizes. ##

## NASA Seeks Science Instruments to Sponsor on Korean Space Agency Lunar Orbiter

[www.nasa.gov/feature/kplo-ao](http://www.nasa.gov/feature/kplo-ao)



September 12, 2016 – NASA is soliciting proposals for scientific instruments that might reveal answers about lunar resources to support the agency’s journey to Mars to fly on a lunar orbiter designed by the Korea Aerospace Research Institute (KARI). The **Korea Pathfinder Lunar Orbiter (KPLO)**, is scheduled to launch in December 2018, and is part of KARI’s Korea Lunar Exploration Program, which aims to robotically explore the Moon through a series of orbiter and lander missions, starting with the KPLO.

KARI has provided 15 kg of KPLO payload space to NASA, for which NASA anticipates selecting up to four instruments to sponsor, with a total budget of \$15 million.

NASA’s objective in selecting instruments is to address “strategic knowledge gaps” or SKGs. in knowledge or information required to reduce risk, increase effectiveness, and improve the design of robotic and human space exploration missions.

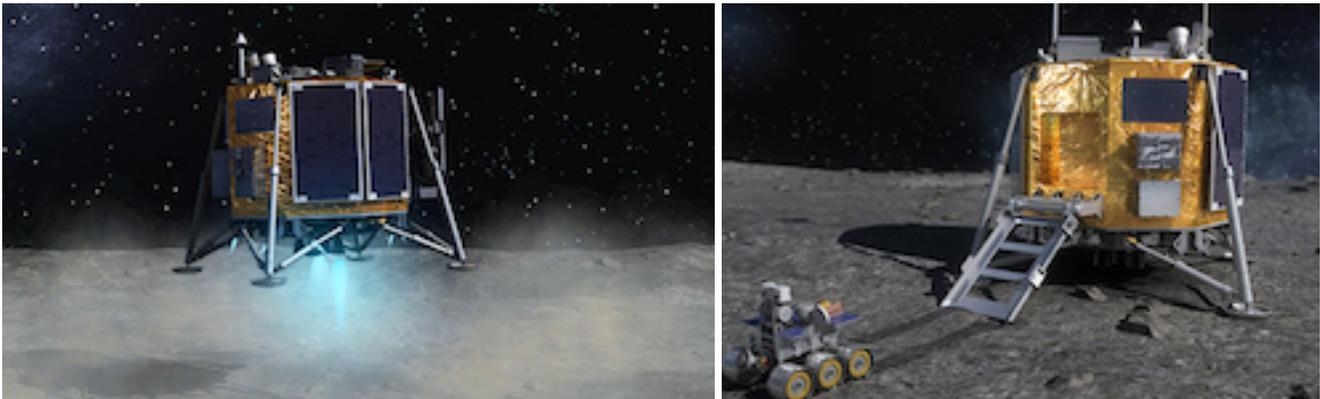
The KPLO mission represents an excellent opportunity for NASA to partner with KARI while contributing to these important knowledge gaps. This opportunity strengthens our understanding the solar system and the potential to harvest its resources for future human exploration. ##

## Korean Lunar Exploration Project

[www.kari.re.kr/eng/sub03\\_04\\_01.do](http://www.kari.re.kr/eng/sub03_04_01.do)

The Korean Lunar Exploration Project involves the development of Korea's first lunar probe and acquisition of the basic technologies needed for lunar exploration – such as an orbiter, a landing module, scientific payload, and deep space communication.

Phase 1: a test orbiter will be developed to attain the key space exploration technology, the deep space network will be built, and the payload will be jointly developed with other countries.



In Phase 2, an unmanned lunar orbiter and a lunar landing module will be developed and launched with the Korean launch system. The lunar probe will be equipped with a scientific payload to analyze the lunar environment and explore its resources, nuclear battery and rover.

Korea has acquired around 70% of the key technologies needed for lunar exploration based on the artificial satellite technologies over the years. Additional technologies such as deep space

communication and deep space navigation will be attained through mutually beneficial international cooperation with organizations such as NASA.

The lunar probe will be launched from a Korean launch vehicle. If the launch is successful in exploring the Moon, it will present an important opportunity to prove the capability of a Korean developed launch vehicle. ##

## India to send Chandrayaan-2 probe to Moon's south pole

<http://www.isro.gov.in/chandrayaan-2>

(no date) – Chandrayaan 2, India's second mission to the Moon, is an advanced version of the previous Chandrayaan-1 mission. It consists of an Orbiter, Lander and Rover configuration. It is planned to be launched as a composite stack into the Earth Parking Orbit (EPO) of 170 X 18,500 km by GSLV-Mk II. The Orbiter carries the combined stack up to the Moon till the Lunar Orbit Insertion (LOI). The combined stack is then inserted into a lunar orbit of 100 km x 100 km. The Lander is separated from the Orbiter in this orbit.

The Orbiter with scientific payloads will orbit around the Moon. The Lander will soft land on the Moon at a specified site and deploy the Rover. The scientific payloads onboard the Orbiter, Lander and Rover are expected to perform mineralogical and elemental studies of the lunar surface.

During 2010, it was agreed that Russian Space Agency ROSCOSMOS would be responsible for lunar Lander and ISRO will be responsible for Orbiter and Rover as well as Launch by GSLV.

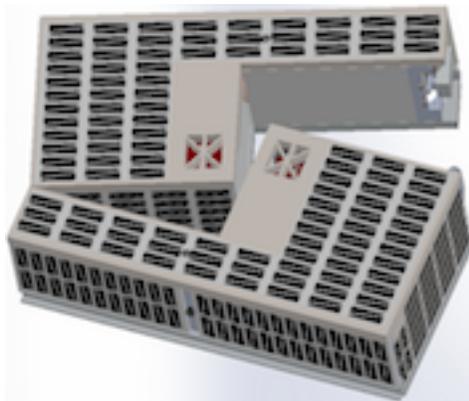
Later, due to a shift in the programmatic alignment of this mission, it was decided that the Lunar Lander development would be done by ISRO and Chandrayaan-2 will be totally an Indian mission. ##

## Exploration Team Shoots for the Moon with Water-Propelled Satellite

[www.space-travel.com/reports/Exploration\\_Team\\_Shoots\\_for\\_the\\_Moon\\_with\\_Water\\_Propelled\\_Satellite\\_999.html](http://www.space-travel.com/reports/Exploration_Team_Shoots_for_the_Moon_with_Water_Propelled_Satellite_999.html)

September 18, 2016 – A satellite propelled by the Earth's most abundant natural resource? Yes, it's true. Cislunar Explorers, a team of Cornell University students is attempting to boldly go where no CubeSat team has gone before: around the Moon.

Not only is the group attempting to make a first-ever Moon orbit with a satellite no bigger than a cereal box, made entirely with off-the-shelf materials, it's doing so with propellant that you can obtain simply by turning on a faucet, **water**.



The Cislunar Explorers are in phase 3 of the four-phase Ground Tournament portion of the **Cube Quest Challenge**, sponsored by NASA's Space Technology Mission Directorate Centennial Challenge Program. The challenge is offering a total of \$5.5 million to teams that meet **the challenge objectives: designing, building and delivering flight-worthy, small satellites capable of advanced operations near and beyond the Moon.** ##

## MOON – HUMAN EXPLORATION & SETTLEMENT & TOURISM

### Russian and US engineers plan manned Moon mission

[www.space-travel.com/reports/While\\_Politicians\\_Fight\\_Russian\\_and\\_US\\_Engineers\\_Plan\\_Manned\\_Moon\\_Mission\\_999.html](http://www.space-travel.com/reports/While_Politicians_Fight_Russian_and_US_Engineers_Plan_Manned_Moon_Mission_999.html) – July 21, 2016 – Engineers in Russia and the US are completing a plan for a collaborative space program. The initiative would preserve the multinational alliance developed when the International Space Station (ISS) was initiated in 1993.

Both American and Russian organizations are considering ways to return to space together, as long as the political relationship between the two nations doesn't deteriorate. The countries had been preparing to part ways after the ISS ceases operation in 2024. ##

### Roscosmos to spend \$7.5M studying issues of manned Moon missions

[www.space-travel.com/reports/Roscosmos\\_to\\_spend\\_7\\_5Mln\\_studying\\_issues\\_of\\_manned\\_lunar\\_missions\\_999.html](http://www.space-travel.com/reports/Roscosmos_to_spend_7_5Mln_studying_issues_of_manned_lunar_missions_999.html)

**August 19, 2015** – The Russian state space corporation Roscosmos will spend 478 million rubles (\$7.5 million) on studying issues of manned flights to the Moon. The Central Research Institute of Machine Building (TsNIIMash), a research institute within the Russian space agency, is set to carry out the studies and develop "key elements and technologies, including in medical and biological areas, to provide safe life and work conditions for cosmonauts on the Lunar orbit and on the surface of the Moon."

### At Least 8 Space Tourists Eye \$150 Mln Moon Trip on Russia's Soyuz

[www.space-travel.com/reports/At\\_Least\\_8\\_Space\\_Tourists\\_Eye\\_150Mln\\_Moon\\_Trip\\_on\\_Board\\_Russia\\_s\\_Soyuz\\_999.html](http://www.space-travel.com/reports/At_Least_8_Space_Tourists_Eye_150Mln_Moon_Trip_on_Board_Russia_s_Soyuz_999.html)

August 23, 2016 – Russia's S.P. Korolev Rocket and Space Corporation (RSC) Energia is preparing a Moon expedition on board an upgraded Soyuz spacecraft with eight space tourists interested in a trip. Energia has been cooperating with the US-based Space Adventures space tourism company to find potential tourists wishing to fly around the Moon.



"We have a preliminary design for upgrading the Soyuz spacecraft, which was conceived with the possibility of organizing a Moon expedition in mind. The upgraded Soyuz will be able to carry out a short flight to the Moon, which will allow it to circle the Moon."

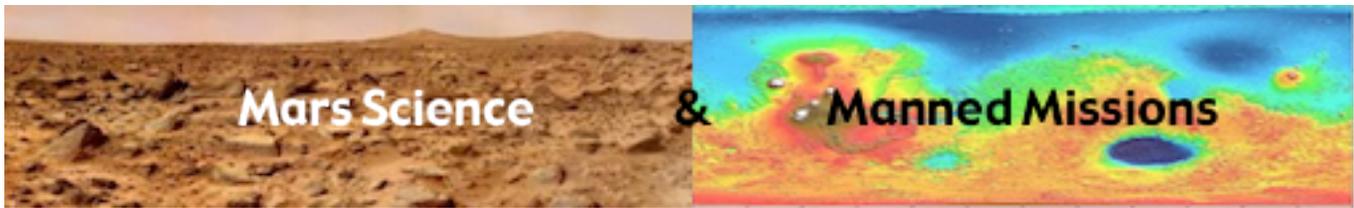
Tickets have been priced at \$150 million per person. Potential tourists have been told that the spaceflight may take place by 2020. ##

### China acquires basic technology for manned lunar missions

[www.spacedaily.com/reports/China\\_acquires\\_basic\\_technology\\_for\\_manned\\_lunar\\_missions\\_999.html](http://www.spacedaily.com/reports/China_acquires_basic_technology_for_manned_lunar_missions_999.html)

September 18, 2016 – China has acquired the basic technology to carry out manned lunar missions. Compared with current missions, the technology used for manned lunar missions are more complex.

In order to achieve the goal of carrying out manned lunar missions, China needs √ rockets with greater load capacity, √ manned aircraft that can land on the lunar surface and return, and √ craft that can shuttle between Earth and the Moon. The Wenchang Satellite Launch Center in southern China's Hainan Province is likely to be the second launch site for China's manned space program. ##



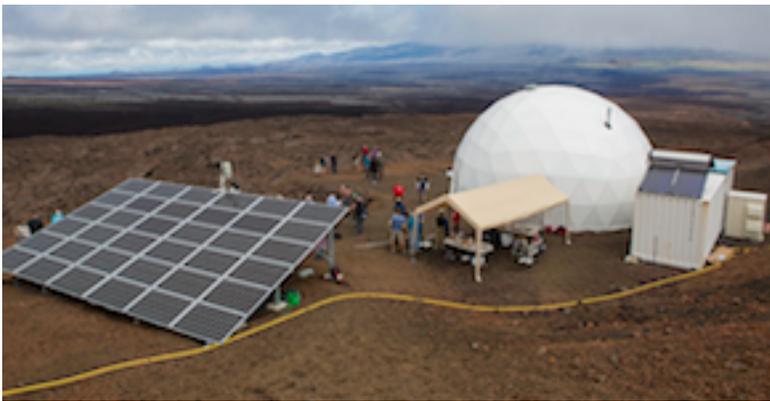
## MARS ANALOG EXERCISES

### Life on Mars: Inside The HI-SEAS Isolation Habitat (Gallery)

[www.space.com/33941-inside-hiseas-isolation-habitat-hawaii.html](http://www.space.com/33941-inside-hiseas-isolation-habitat-hawaii.html)

[www.space.com/33927-what-its-like-on-mock-mars.html](http://www.space.com/33927-what-its-like-on-mock-mars.html)

September 1, 2016 – Space.com had the chance to visit the isolation habitat where six people lived for one year, largely cut off from the outside world. The HI-SEAS program (Hawaii Space Exploration Analog and Simulation) was established to study the effects of isolation and confinement on human beings, in preparation for sending humans to places like Mars.



The HI-SEAS crewmembers lived together in the 1,200-sq-ft (110 sq m) habitat; while they could communicate with the outside world via email (with a **20-minute delay**)\*, they had no physical contact with anyone else. They could exit the habitat only in spacesuits, and had to otherwise live like astronauts would on Mars.

[\* **The actual time delay in Earth-Mars and Mars-Earth communications** would range from 3 – 21 minutes (one way, 6–42 minutes between message sent and response received, as the distance between Earth and Mars varies from 55–378 million km (34 – 235 million mi).]

### 160-Day Mock Mars Mission Begins September 24 in Utah

[www.space.com/34137-mock-mars-mission-mdrs-utah.html](http://www.space.com/34137-mock-mars-mission-mdrs-utah.html)

[www.space.com/34178-160-day-mars-society-mission-begins-utah.html](http://www.space.com/34178-160-day-mars-society-mission-begins-utah.html)

September 23, 2016 – On Saturday (Sept. 24), the crewmembers of the Mars 80 mission — who hail from France, Japan, Russia, Australia, India and Canada — will begin work at the Mars Desert Research Station (MDRS), a facility in the Utah desert run by the nonprofit Mars Society.

The team will conduct a campaign of geology, microbiology and paleontology research in the area, operating under many of the same pressures and constraints that real-life Mars pioneers would face. Crewmembers will also test out spacesuit technologies and other gear that could help humanity get a foothold on the Red Planet.

**Editor:** We were privileged to be a part of MDRS Hab overhaul Crew 36 in 2005, and Captain of MDRS Crew 45 in 2006.

[http://legacy.moonsociety.org/reports/ams1\\_summary.html](http://legacy.moonsociety.org/reports/ams1_summary.html) ##

## SpaceX's 2018 'Red Dragon' Mission Could Help NASA Put Boots on Mars

[www.space.com/34164-spacex-red-dragon-mars-mission-nasa.html](http://www.space.com/34164-spacex-red-dragon-mars-mission-nasa.html)

September 23, 2016 – SpaceX's planned 2018 Mars mission could pave the way for a few different types of boot prints on the Red Planet.

Space-X aims to launch one of its uncrewed Dragon capsules toward Mars in May 2018, to test out some of the technologies needed to make SpaceV's ambitious Mars colonization goal a reality.

One of those technologies is "**supersonic retropropulsion.**" Dragon will hit the Martian atmosphere going far faster than the speed of sound; the capsule will use its onboard SuperDraco thrusters, rather than parachutes, to slow down enough to land.

NASA views the strategy as key to enabling human Mars missions, which will require putting extremely heavy payloads such as habitat modules down on the planet's surface. (NASA's 1-ton Curiosity rover, which touched down in August 2012, pretty much maxed out the agency's daring parachute-sky-crane landing system.

That helps explain why the space agency is providing technical support to the 2018 "Red Dragon" mission in a range of areas, from deep-space communication to the drafting of "planetary protection" protocols designed to reduce the risk of contaminating Mars with Earth microbes. ##

## Elon Musk Plans to Name 1st Mars Colony Ship 'Heart of Gold'

[www.space.com/34220-spacex-first-mars-ship-hitchhikers-guide-galaxy.html](http://www.space.com/34220-spacex-first-mars-ship-hitchhikers-guide-galaxy.html)

September 28, 2016 – SpaceX plans to name the first of its many Mars colonizing ships after "Heart of Gold," a spaceship in Douglas Adams' "The Hitchhiker's Guide to the Galaxy."

## SpaceX's Elon Musk Unveils Interplanetary Spaceship to Colonize Mars

[www.space.com/34210-elon-musk-unveils-spacex-mars-colony-ship.html](http://www.space.com/34210-elon-musk-unveils-spacex-mars-colony-ship.html) (with Video)

[www.space.com/34213-spacex-interplanetary-transport-mars-flights-in-images.html](http://www.space.com/34213-spacex-interplanetary-transport-mars-flights-in-images.html)

## A giant impact: Solving the mystery of how Mars' moons formed

July 4, 2016 – <http://phys.org/news/2016-07-giant-impact-mystery-mars-moons.html>



"The origin of the two Martian moons, Phobos and Deimos, remained a mystery. Due to their small size and irregular shape, they strongly resembled asteroids, but no one understood how Mars could have " captured " them and made them into satellites with almost circular and equatorial orbits. According to a competing theory, toward the end of its formation Mars suffered a giant collision with a protoplanet: but why did the debris from such an impact create two small satellites instead of one enormous moon, like the Earth's? A third possibility is that Phobos and Deimos formed at the same time as Mars, which would entail that they have the same composition as their planet, although their low density seems to contradict this hypothesis. Two independent studies have now solved the puzzle: the Martian moons must have arised from a giant collision."

## Mars Canyons study adds clues about possible Water

[www.marsdaily.com/reports/Mars\\_Canyons\\_Study\\_Adds\\_Clues\\_about\\_Possible\\_Water\\_999.html](http://www.marsdaily.com/reports/Mars_Canyons_Study_Adds_Clues_about_Possible_Water_999.html)

July 12, 2016 – Some of the sites displaying the seasonal flows are canyon ridges and isolated peaks, ground shapes that make it hard to explain the streaks as resulting from underground water directly

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

reaching the surface. It is highly unlikely that shallow ground ice would be present as a source for seasonal melting, given the warm temperatures in the equatorial canyons. Water pulled from the atmosphere by salts, or mechanisms with no flowing water involved, remain possible explanations for the features at these sites.

## NASA Selects Five Mars Orbiter Concept Studies

July 18, 2016 – [www.marsdaily.com/reports/NASA\\_Selects\\_Five\\_Mars\\_Orbiter\\_Concept\\_Studies\\_999.html](http://www.marsdaily.com/reports/NASA_Selects_Five_Mars_Orbiter_Concept_Studies_999.html)

NASA has selected five U.S. aerospace companies to conduct concept studies for a potential future Mars orbiter mission. Such a mission would continue key capabilities including telecommunications and global high-resolution imaging in support of the agency's Journey to Mars. The companies are: The **Boeing** Company in Huntington Beach, California; **Lockheed Martin** Space Systems in Denver; **Northrop Grumman** Aerospace Systems in Redondo Beach, California; **Orbital ATK** in Dulles, Virginia; and **Space Systems/Loral** in Palo Alto, California.

## Digging deeper into Mars

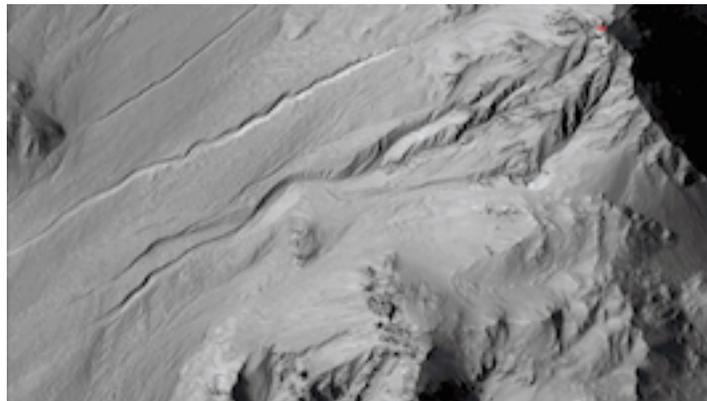
July 25, 2016 – <http://phys.org/news/2016-07-deeper-mars.html>

Scientists continue to unravel the mystery of life on Mars by investigating evidence of water in the planet's soil. Previous observations of soil observed along crater slopes on Mars showed a significant amount of perchlorate salts, which tend to be associated with brines with a moderate pH level.

But a different chemical on Mars may be key. The researchers found that the bulk soil on Mars, across regional scales the size of the U.S. or larger, likely contains iron sulfates bearing chemically bound water, which typically result in acidic brines. This new observation suggests that iron sulfates may play a major role in hydrating martian soil.

## Mars' gullies likely not formed by liquid water

July 29, 2016 – <http://phys.org/news/2016-07-mars-gullies-liquid.html>



Martian gullies as seen in the image from NASA's Mars Reconnaissance Orbiter resemble gullies on Earth that are carved by liquid water.

Scientists use the term "gully" for features on Mars that share three characteristics in their shape: an alcove at the top, a channel, and an apron of deposited material at the bottom. Gullies are distinct from another type of feature on Martian slopes, streaks called "recurring slope lineae," or RSL, which are distinguished by seasonal darkening and fading, rather than characteristics of how the ground is shaped. Water in the form of hydrated salt has been identified at RSL sites. The new study focuses on gullies and their formation process by adding composition information to previously acquired imaging. ##

## Opportunity Rover Studying Grooves

August 19, 2016 – [www.marsdaily.com/reports/Opportunity\\_rover\\_studying\\_grooves\\_999.html](http://www.marsdaily.com/reports/Opportunity_rover_studying_grooves_999.html)

Opportunity is wrapping up exploration of 'Marathon Valley' on the rim of Endeavour Crater. The rover has driven to an area where the rock outcrop has interesting grooves. The science team is using Opportunity to conduct an extensive visual documentation campaign at this area. The rover is collecting both short-baseline and long-baseline multi-spectral stereo image data with the Panoramic Camera (Pancam). ##

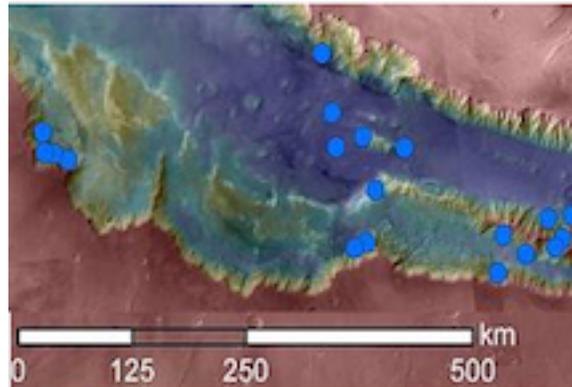
This issue is online at: <http://legacy moonsociety.org/international/ttsiq/> and at: [www.nss.org/tothestars/](http://www.nss.org/tothestars/)

## Test for damp ground at Mars' seasonal streaks finds none

[www.marsdaily.com/reports/Test\\_for\\_damp\\_ground\\_at\\_Mars\\_seasonal\\_streaks\\_finds\\_none\\_999.html](http://www.marsdaily.com/reports/Test_for_damp_ground_at_Mars_seasonal_streaks_finds_none_999.html)

August 25, 2016 – Seasonal dark streaks on Mars that have become one of the hottest topics in interplanetary research don't hold much water, according to the latest findings from NASA's Mars Odyssey mission rely on ground temperature, measured by infrared imaging using the spacecraft's Thermal Emission Imaging System (THEMIS).

They do not contradict last year's identification of hydrated salt at these flows, which since their 2011 discovery have been regarded as possible markers for the presence of liquid water on modern Mars. However, the temperature measurements now identify an upper limit on how much water is present at these darkened streaks: about as much as in the driest desert sands on Earth.



Blue dots on this map indicate sites of recurring slope lineae (RSL) in part of the Valles Marineris canyon network on Mars. RSL are seasonal dark streaks that may indicate liquid water. This area has the highest density of known RSL on Mars. ##

## Mars Rover Views Spectacular Layered Rock Formations

[www.marsdaily.com/reports/Mars\\_Rover\\_Views\\_Spectacular\\_Layered\\_Rock\\_Formations\\_999.html](http://www.marsdaily.com/reports/Mars_Rover_Views_Spectacular_Layered_Rock_Formations_999.html)

September 12, 2016 – This view from the Mast Camera (Mastcam) in NASA's Curiosity Mars rover shows sloping buttes and layered outcrops within the "Murray Buttes" region on lower Mount Sharp.

The buttes and mesas rising above the surface are eroded remnants of ancient sandstone that originated when winds deposited sand after lower Mount Sharp had formed. Curiosity closely examined that layer -- called the "Stimson formation" -- during the first half of 2016, while crossing a feature called "Naukluft Plateau" between two exposures of the Murray formation. The layering within the sandstone is called "cross-bedding" and indicates that the sandstone was deposited by wind as migrating sand dunes.



Full size image [www.jpl.nasa.gov/spaceimages/images/largesize/PIA21042\\_hires.jpg](http://www.jpl.nasa.gov/spaceimages/images/largesize/PIA21042_hires.jpg)

## **Mars hosted lakes, snowmelt-fed streams much later than previously thought** [www.marsdaily.com/reports/Mars\\_hosted\\_lakes\\_snowmelt-fed\\_streams\\_much\\_later\\_than\\_previously\\_thought\\_999.html](http://www.marsdaily.com/reports/Mars_hosted_lakes_snowmelt-fed_streams_much_later_than_previously_thought_999.html)

September 15, 2016 – Researchers at NASA have found evidence that water flowed on Mars much more recently than previously thought -- perhaps millions of years more recently. Scientists have previously documented an ancient era in Mars history featuring extremely wet conditions. But new observations -- collected by the Mars Reconnaissance Orbiter and analyzed by scientists at the Jet Propulsion Laboratory -- have revealed the presence of lakes and snowmelt-fed streams a billion years later.

"We discovered **valleys that carried water into lake basins. Several lake basins filled and overflowed**, indicating there was a considerable amount of water on the landscape during this time."##

## **Some ancient Mars lakes came long after others**

<http://phys.org/news/2016-09-ancient-mars-lakes.html>

September 15, 2016 – Lakes and snowmelt-fed streams on Mars formed much later than previously thought possible, according to new findings using data primarily from NASA's Mars Reconnaissance Orbiter. The recently discovered lakes and streams appeared roughly a billion years after a well-documented, earlier era of wet conditions on ancient Mars. These results provide insight into the climate history of the Red Planet and suggest the surface conditions at this later time may also have been suitable for microbial life.

"We discovered **valleys that carried water into lake basins/ Several lake basins filled and overflowed**, indicating there was a considerable amount of water on the landscape during this time." ##

## **Hebridean rock provides clue to life on Mars**

<http://phys.org/news/2016-09-hebridean-clue-life-mars.html>

September 16, 2016 – Analysis of rocks in the Outer Hebrides has provided a tantalising clue that Mars may contain habitats which can potentially support life. Researchers studying rocks on Barra and the Uists have demonstrated that hydrogen – which is essential for life – is formed by earthquakes. On Mars there are 'Marsquakes' which may produce hydrogen in the same way.

Earthquakes cause friction, and analysis of ancient rock in the Outer Hebrides has demonstrated how this creates hydrogen. Hydrogen is a fuel for simple microbes, so microbes could live off hydrogen created in the Earth's subsurface as a result of seismic activity. This is a model that could apply to any other rocky planet, and on Mars there are so-called 'Marsquakes' that may produce hydrogen and therefore could feed life in the Martian sub-surface. ##

## **Earthquakes, 'Marsquakes,' and the Possibility of Life**

[www.spacedaily.com/reports/Earthquakes\\_Marsquakes\\_and\\_the\\_Possibility\\_of\\_Life\\_999.html](http://www.spacedaily.com/reports/Earthquakes_Marsquakes_and_the_Possibility_of_Life_999.html)

September 19, 2016 – A new study shows that rocks formed by the grinding together of other rocks during earthquakes are rich in trapped hydrogen – a finding that suggests similar seismic activity on Mars may produce enough hydrogen to support life.

Previous work has suggested that hydrogen is produced during earthquakes when rocks fracture and grind together. New measurements suggest that enough hydrogen is produced to support the growth of microorganisms around active faults. ##

## **Mars 2020 rover to produce oxygen: NASA**

[www.marsdaily.com/reports/NASAs\\_Mars\\_2020\\_Rover\\_to\\_Produce\\_Oxygen\\_on\\_the\\_Red\\_Planet\\_999.html](http://www.marsdaily.com/reports/NASAs_Mars_2020_Rover_to_Produce_Oxygen_on_the_Red_Planet_999.html)

September 21, 2016 – NASA's Mars 2020 rover will not only investigate the Red Planet, searching for evidence of past life on Mars, but one of the mission's instrument called MOXIE will have a special task, testing technology essential for Mars colonization.

MOXIE stands for the Mars Oxygen In-Situ Resource Utilization Experiment. With a diameter of 9.4 x 9.4 x 12.2 inches (23.9 x 23.9 x 30.9 centimeters), the instrument will produce oxygen from the Martian carbon-dioxide atmosphere at a rate of about 0.022 lbs. (10 grams) per hour. It is a 1:100 scale test model of a future instrument that would be efficient for human explorers on Mars.

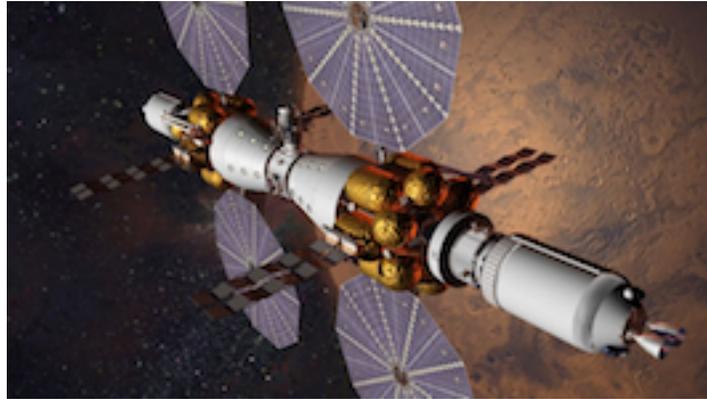
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## Mars Space Station Could Pave Way for 1st Footsteps on Red Planet

[www.space.com/33692-mars-space-station-surface-missions.html](http://www.space.com/33692-mars-space-station-surface-missions.html)

August 15, 2016 – Humanity may camp out for a year or so in Mars orbit to get ready for its epic first trek to the Red Planet's surface.



Artist illustration of the "Mars Base Camp" space station proposed by Lockheed Martin.

Lockheed Martin recently proposed that NASA work with its international partners and private industry to set up a space station in Mars orbit by 2028. Astronauts working and living aboard this "Mars Base Camp" could help collect information that any future Red Planet explorer would need to know. ##

## Antarctica Provides ICE to Study Behavior Effects in Astronauts

[www.spacedaily.com/reports/Antarctica\\_Provides\\_ICE\\_to\\_Study\\_Behavior\\_Effects\\_in\\_Astronauts\\_999.html](http://www.spacedaily.com/reports/Antarctica_Provides_ICE_to_Study_Behavior_Effects_in_Astronauts_999.html)

September 15 2016 – NASA's journey to Mars includes preparing astronauts to cope with several months of isolation, confinement, and in an extreme environment (identified with the acronym ICE). One of the best ways to study this on Earth is by observing others who also spend several months on actual ice in Antarctica.

It's relatively simple to place subjects in isolation or confinement for the purpose of studying mood and behavior, but the extreme environment element is harder to find.

Sometimes called "White Mars," Antarctica is perfect because "you can't walk off the ice. That goes for whether you're having a health, behavioral health or a personal issue, you're not going anywhere. That is very similar to spaceflight. It changes your mindset about how you are going to respond when you know you can't leave."

## Elon Musk Says SpaceX' New Spaceship Could Go 'Well Beyond Mars'

[www.space.com/34115-spacex-mars-colony-spaceship-elon-musk.html](http://www.space.com/34115-spacex-mars-colony-spaceship-elon-musk.html)



September 19, 2016 – "Mars Colonial Transporter" seems like a pretty cool name for a spaceship, but it wasn't quite ambitious enough for SpaceX founder and CEO Elon Musk.

"MCT can go well beyond Mars, so we need a new name: "Interplanetary Transport System" (ITS).

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Musk has said repeatedly that he founded SpaceX in 2002 primarily to colonize Mars and thereby make humanity a multiplanet species. The company plans to launch an uncrewed mission to Mars in 2018 using SpaceX's Dragon capsule and Falcon Heavy rocket, then follow that up with additional missions every 26 months for the foreseeable future.

## What We Need to Know Before Landing Astronauts on Mars

[www.space.com/34160-what-manned-mars-missions-need-to-know.html](http://www.space.com/34160-what-manned-mars-missions-need-to-know.html)

September 23, 2016 – Elon Musk and his SpaceX rocketeers are blueprinting a plan to land humans on Mars in 2025 and to land payloads onto the Red Planet's surface at each 26 month opportunity starting in 2018. A similar timeline may be pursued by other players.

That as a given, a specially convened "ePanel" of Mars experts recently tackled a specific question: If humans do land on Mars in 2025 what do we absolutely need to know from the surface of Mars before that time and specifically what measurements and demonstrations need to be done with the 2018 and later precursor landers to make that possible?

The report, now in draft form, is called "**Essential Precursor Activities for a Near-Term Human Mars Mission.**" It is the output from an independent virtual panel of researchers.

The exercise had neither encouragement nor approval from SpaceX nor NASA. The draft report underscores the fact that there are a number of "**clear and pressing issues that need to be addressed as soon as possible.**"

### Primary concerns

- Crew safety
- Dangers to crew from exposure to surface materials and toxic chemistry
- Dangers to crew from possible pathogens
- Contamination of the Martian surface by crew-transported organisms from Earth
- Return of (unlikely but possible) pathogens damaging to Earth's biological balance
- Availability of resources useful for human activities including life sustaining materials. ##

## Elon Musk Unveils SpaceX Raptor Engine Test for Interplanetary Transport

[www.space.com/34192-spacex-raptor-rocket-test-first-photos.html](http://www.space.com/34192-spacex-raptor-rocket-test-first-photos.html)

September 26, 2016 – SpaceX has successfully test-fired the new Raptor rocket engine that will launch the company's planned interplanetary spaceship. The engine is being developed to help propel a powerful reusable rocket to Mars and beyond as part of SpaceX's Interplanetary Transport System.

## Breathtaking Videos Shows How SpaceX Will Send People to Mars

Sept 27, 2016 – [www.space.com/34211-spacex-mars-interplanetary-transport-concept-video.html](http://www.space.com/34211-spacex-mars-interplanetary-transport-concept-video.html)  
[www.space.com/34209-spacex-mars-spaceship-animation.html](http://www.space.com/34209-spacex-mars-spaceship-animation.html)

## Elon Musk unveils plan for Mars 'city'

<http://phys.org/news/2016-09-spacex-ceo-musk-mind-mars.html>

September 27, 2016 – Musk showed a futuristic video depicting his concept of an interplanetary transport system based on re-usable rockets, a propellant farm on Mars and 1,000 spaceships on orbit, carrying about 100 people each.

- The spacecraft would have a restaurant, cabins, zero-gravity games and movies.
- It has to be fun or exciting. It can't feel cramped or boring,
- The first flight would be expensive but the aim is making this affordable to almost anyone who wants to go, by **dropping the price of a ticket over time to \$100,000.**
- Millions of tons of cargo would also need to blast off aboard a powerful rocket, a scaled-up version of the Falcon 9 booster, the company's current rocket system that can land vertically.
- The plan would require "**a huge public-private partnership**" to establish a self-sustaining human civilization on Mars. ##

## 'Destination: Mars' Virtual Reality Experience Open at Kennedy Space Center

[www.space.com/34129-destination-mars-now-open-kennedy.html](http://www.space.com/34129-destination-mars-now-open-kennedy.html)

[www.marsdaily.com/reports/A\\_Mixed\\_reality\\_Trip\\_to\\_Mars\\_999.html](http://www.marsdaily.com/reports/A_Mixed_reality_Trip_to_Mars_999.html)



September 21, 2016 – Real-life astronaut Buzz Aldrin introduced his virtual counterpart Sunday (Sept. 18) at the Kennedy Space Center Visitor Complex in Florida, previewing a new "mixed reality" exhibit that lets visitors explore the surface of Mars with a virtual Aldrin as their guide. The exhibit officially opened to the public Monday (Sept. 19) and will be **open until the end of the year.** ##

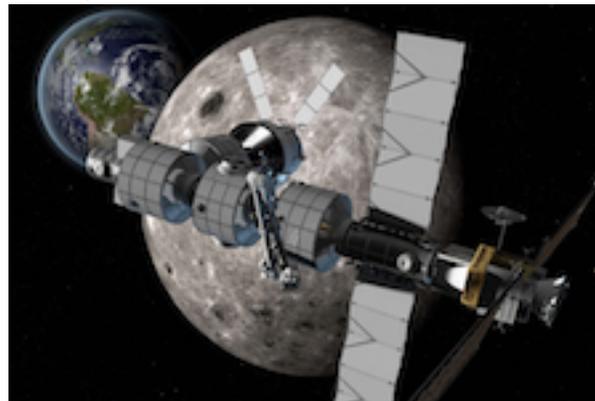
## Boeing Eyes Moon-Orbiting Space Station as Waypoint to Mars

[www.space.com/34208-boeing-mars-plan-needs-moon-space-station.html](http://www.space.com/34208-boeing-mars-plan-needs-moon-space-station.html)

September 27, 2016 – Boeing has a grand plan to build a **crewed space station in orbit around the Moon**, as a proving ground for the technologies and procedures needed to send astronauts even farther out, to Mars. **"We need to take the capabilities that we're developing on station, take them to the next level and test them a little farther away. And that's the idea of going to cislunar space."**

Boeing's plan involves assembling the station **between 2021 and 2025** by using payload space available on five launches of NASA's Space Launch System (SLS) and Orion spacecraft.

The five components of the station include ✓ two habitat modules, ✓ an airlock, ✓ a logistics module, and ✓ a power bus and augmentation module.



An artist's rendition of a cis-lunar space station, which the Boeing has proposed as a stepping stone on the path to human missions to Mars.##

## ADVANCED ROCKET TECHNOLOGY FOR MARS AND BEYOND

### Elon Musk Unveils SpaceX Raptor Engine Test for Interplanetary Transport

[www.space.com/34192-spacex-raptor-rocket-test-first-photos.html](http://www.space.com/34192-spacex-raptor-rocket-test-first-photos.html)

September 26, 2016 – SpaceX has successfully test-fired the new Raptor rocket engine that will launch the company's planned interplanetary spaceship. The engine is being developed to help propel a powerful reusable rocket to Mars and beyond as part of SpaceX's Interplanetary Transport System.

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## ASTEROIDS

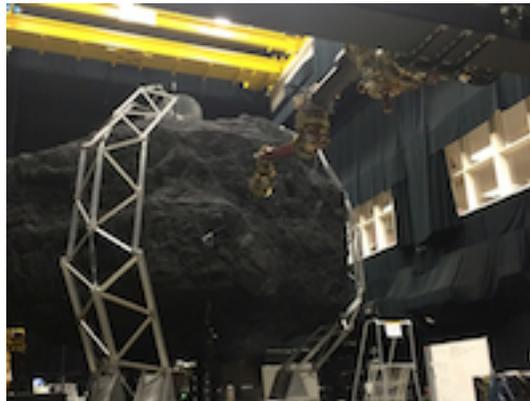
### NASA to map the surface of an asteroid

July 25, 2016 - <http://phys.org/news/2016-07-nasa-surface-asteroid.html>

NASA's OSIRIS-REx spacecraft will launch September 2016 and travel to a near-Earth asteroid known as Bennu to harvest a sample of surface material and return it to Earth for study. The science team will be looking for something special. Ideally, the sample will come from a region in which the building blocks of life may be found.

### NASA's Asteroid Redirect Mission Emerges from First Planning Stages

August 11, 2016 - [www.space.com/33761-nasa-asteroid-redirect-mission-design-milestone.html](http://www.space.com/33761-nasa-asteroid-redirect-mission-design-milestone.html)  
[www.space.com/20606-nasa-asteroid-capture-mission-images.html](http://www.space.com/20606-nasa-asteroid-capture-mission-images.html)



NASA's **Asteroid Redirect Mission**(ARM) has passed a key design milestone, bringing the project one step closer to snagging a boulder off an asteroid and pulling that piece into orbit around the moon.

The complex mission is currently targeted to launch in 2021, pegged at a cost of \$1.4 billion. After launch, the rocket will travel to a large near-Earth asteroid, collect a large boulder off of the asteroid's surface and pull that piece to the Moon.

Later, astronauts will travel to the boulder to extract and analyze samples. While orbiting the asteroid, the spacecraft can also tug the asteroid off-course using the craft's and boulder's combined gravity (as a proof-of-concept for deflecting a threatening body).

The mission has passed a milestone called Key Decision Point-B (KDP-B) and it will be able to move on to its Phase B planning stage. By the end of Phase B, ARM will have an approved baseline mission and design that meets all the agreed-upon requirements, in a process that all NASA missions pass through. ##

### Why NASA Picked Space Rock Bennu for Its Asteroid-Sampling Mission

[www.space.com/33987-why-nasa-picked-asteroid-bennu-osiris-rex-mission.html](http://www.space.com/33987-why-nasa-picked-asteroid-bennu-osiris-rex-mission.html)

September 7, 2016 - NASA had literally thousands of potential targets for its asteroid-sampling OSIRIS-REx mission. But the agency decided on a space rock named Bennu, because the asteroid checks off three important boxes.

Bennu's ✓ **Size**, ✓ **Primitive and Carbon-Rich Composition** and ✓ **Orbit** make it one of the most fascinating and accessible asteroids, and that is why it was ultimately chosen as the target asteroid for the mission. ##

## Next Stop, Bennu! NASA Launches Bold Asteroid-Sampling Mission

[www.space.com/34007-nasa-launches-osiris-rex-asteroid-sampling-mission.html](http://www.space.com/34007-nasa-launches-osiris-rex-asteroid-sampling-mission.html)

[www.space.com/34014-blastoff-osiris-rex-launches-to-asteroid-bennu-video.html](http://www.space.com/34014-blastoff-osiris-rex-launches-to-asteroid-bennu-video.html)

[www.space.com/34013-nasa-osiris-rex-asteroid-mission-launch-photos.html](http://www.space.com/34013-nasa-osiris-rex-asteroid-mission-launch-photos.html)

September 8, 2016 = NASA's OSIRIS-REx spacecraft **lifts off** from Cape Canaveral Air Force Station Sept. 8, riding a United Launch Alliance Atlas V rocket its seven-year mission to go to the asteroid Bennu and back,

OSIRIS-REx will rendezvous with a 1,640-ft-wide (500 m) asteroid named Bennu in August 2018, snag some dirt and pebbles off the space rock two years later, and deliver this cosmic sample to Earth in September 2023 ##

## Visit to 'Armageddon Asteroid' Bennu Could Save Future Earth from Impact

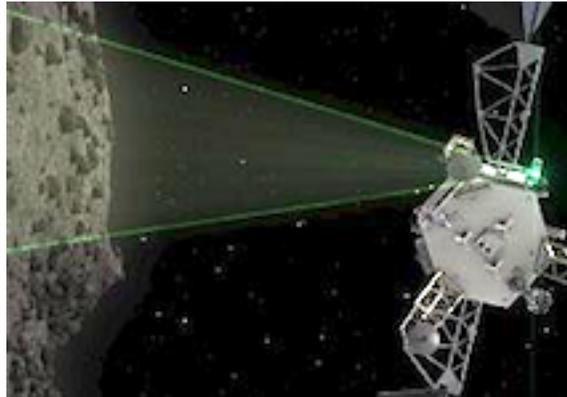
[www.space.com/34016-why-osiris-rex-is-visiting-an-asteroid.html](http://www.space.com/34016-why-osiris-rex-is-visiting-an-asteroid.html)

September 9, 2016 = The target of the OSIRIS-REx mission, an asteroid known as Bennu, circles the Sun just inside the orbit of Mars (occasionally crossing Earth's orbital path). Although Bennu is unlikely to collide with our planet, understanding its composition could help scientists figure out how to deflect other rocky bodies that may be on a crash course with Earth. ##

## JPL seeks robotic spacecraft development for Asteroid Redirect Mission

[www.spacedaily.com/reports/JPL\\_Seeks\\_Robotic\\_Spacecraft\\_Development\\_for\\_Asteroid\\_Redirect\\_Mission\\_999.html](http://www.spacedaily.com/reports/JPL_Seeks_Robotic_Spacecraft_Development_for_Asteroid_Redirect_Mission_999.html)

September 22, 2016 – NASA's Jet Propulsion Laboratory in Pasadena, California, has issued a request for proposal seeking design, development and build of the robotic spacecraft that will capture a multi-ton asteroid boulder from deep space during the first segment of the agency's Asteroid Redirect Mission (ARM). ARM is a two-part mission that will integrate robotic and crewed spacecraft operations in the proving ground of deep space to demonstrate key capabilities needed for NASA's Journey to Mars.



This graphic depicts the Asteroid Redirect Vehicle conducting a flyby of its target asteroid. During these flybys, ARM would come within 0.6 miles (1 kilometer), generating imagery with resolution of up to 0.4 of an inch (1 centimeter) per pixel.

The RFP is open to 4 industry partners that previously completed conceptual designs of the spacecraft. #

## Incoming new warning system tracks potentially dangerous asteroids

[www.space.com/34149-asteroid-impact-warning-system-scout.html](http://www.space.com/34149-asteroid-impact-warning-system-scout.html)

[www.spacedaily.com/reports/NASA\\_Creates\\_Software\\_to\\_Keep\\_Tabs\\_on\\_Killer\\_Asteroids\\_999.htm](http://www.spacedaily.com/reports/NASA_Creates_Software_to_Keep_Tabs_on_Killer_Asteroids_999.htm)

September 23, 2016 – A new early warning system may help speed up calculations of when and where incoming asteroids could strike Earth. By monitoring observations of newly reported space objects, a computer program called Scout can quickly identify potentially dangerous asteroids, then automatically call for follow-ups to calculate a more precise path for these bodies. These are objects that observers have reported, and they suspect them to be asteroids.

While midsize asteroids are frequently identified well before they hit Earth, smaller objects can be more difficult to spot and classify ahead of time. Correctly classifying them and determining their orbits takes multiple observations, and, especially for potentially hazardous impactors, the sooner the better.

On Oct. 7, 2008, an 80-ton rock plowed through Earth's atmosphere and exploded above a remote area in Sudan. The asteroid, known as 2008 TC3, was spotted just 19 hours before it reached the African desert, making this **the first incoming object tracked before crashing into Earth.**

But the short notice provided little time for astronomers to follow up. With this in mind, NEO researchers at JPL, have worked to create a **program to automatically monitor new observations and alert fellow astronomers.** ##

## "DWARF PLANET" CERES

### Dawn maps Ceres craters where ice can accumulate

July 9, 2016 - <http://phys.org/news/2016-07-dawn-ceres-craters-ice-accumulate.html>

At the poles of Ceres, scientists have found craters that are permanently in shadow (indicated by blue markings). Such craters are called "cold traps" if they remain below about minus 240 degrees Fahrenheit (minus 151 degrees Celsius).

### Study shows puzzling paucity of large craters on dwarf planet Ceres

[www.spacedaily.com/reports/SwRI\\_led\\_study\\_shows\\_puzzling\\_paucity\\_of\\_large\\_craters\\_on\\_dwarf\\_planet\\_Ceres\\_999.html](http://www.spacedaily.com/reports/SwRI_led_study_shows_puzzling_paucity_of_large_craters_on_dwarf_planet_Ceres_999.html)

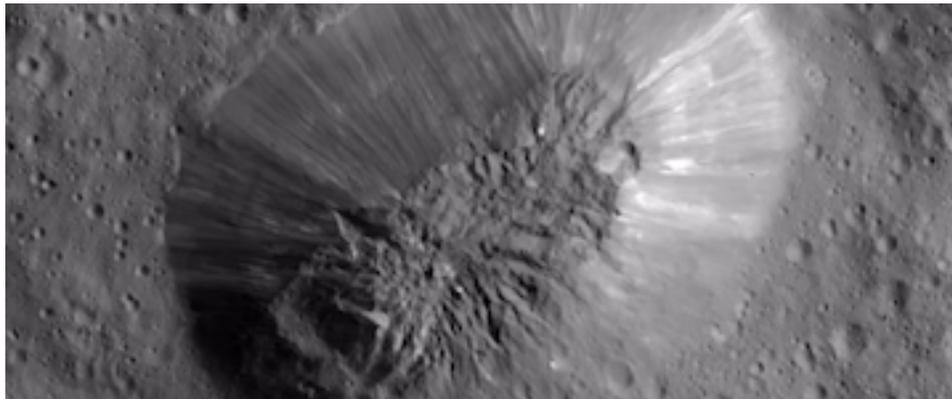
July 28, 2016 - A team of scientists led by Southwest Research Institute (SwRI) made a puzzling observation while studying the size and distribution of craters on the dwarf planet Ceres, the largest object in the Main Asteroid Belt between Mars and Jupiter.

Collision models predicted Ceres should have accumulated up to 10-15 craters larger than 400 kilometers (250 mi) wide, and at least 40 craters larger than 100 km (62 mi) wide. Instead, NASA's Dawn spacecraft found only 16 craters larger than 100 km, and none larger than 280 km (175 mi) across. ##

### Ice Volcanoes and More: Dwarf Planet Ceres Continues to Surprise

[www.space.com/33934-dwarf-planet-ceres-ice-volcano-discoveries.html](http://www.space.com/33934-dwarf-planet-ceres-ice-volcano-discoveries.html)

[www.space.com/33935-dwarf-planet-ceres-probably-has-ice-volcano-nasa-dawn-mission-reveals-video.html](http://www.space.com/33935-dwarf-planet-ceres-probably-has-ice-volcano-nasa-dawn-mission-reveals-video.html)



An Ice Volcano on Ceres

September 1 2016 - The dwarf planet Ceres is a complex and active world unlike any other place in the solar system, new research suggests.

Observations by NASA's Ceres-orbiting Dawn spacecraft indicate that "ice volcanos" have erupted on the dwarf planet **in the recent past** and that **Ceres' crust is an odd ice-rock mixture that has never been observed before**, scientists reported in a series of six new studies published online today (Sept. 1) in the journal **Science.** ##

**Editor:** It has been suggested before Dawn's arrival, that Ceres may have an ocean below its thick ice crust. Below is a current interpretation of what happened to that "ocean."

<http://phenomena.nationalgeographic.com/2016/03/23/ceres-the-dwarf-planet-formerly-known-as-an-ocean-world/>

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

Update, June 29, 2016: The composition of Ceres' bright spots is no longer a mystery: In **Nature**, scientists revealed those enigmatic splotches are rich in sodium carbonate, a salt tightly linked to watery conditions on Earth. In fact, there's so much of the stuff in Ceres' Occator crater that the pit holds the record for the largest such deposit in the solar system aside from Earth.

Just how those salts ended up on Ceres' surface is still a mystery, though. Instead of containing large amounts of ice, as some scientists had expected, Ceres' interior is considerably drier than suspected, reports a second study published in Nature Geoscience. That makes it hard to explain how the dwarf planet's surface ended up covered in formerly dissolved salts.

Now, researchers are trying to sort out how Ceres made those salts and moved liquid brines to the surface; they suspect impacts may be to blame for simultaneously melting buried ice and excavating the planet's salty sea, leaving bits of it to shimmer in the sunlight. ##

## COMETS

### Farewell Philae: Earth severs link with silent comet probe (Update)

July 27, 2016 – <http://phys.org/news/2016-07-goodbye-philae-earth-severs-link.html>

Earth bid a final farewell to robot lab Philae on Wednesday, severing communications after a year-long silence from the pioneering probe hurtling through space on a comet. \*\*

### How comets are born

<http://phys.org/news/2016-07-comets-born.html>

Evidence that Comet 67P/Churyumov-Gerasimenko is composed of ancient material preserved from the formation of the early Solar System and that came together under low speed. Detailed analysis of data collected by Rosetta show that comets are the ancient leftovers of early Solar System formation, and not younger fragments resulting from subsequent collisions between other, larger bodies ##

### Hubble Telescope Snaps Best-Ever Views of a Comet's Disintegration

[www.space.com/34092-comet-disintegration-hubble-telescope-photos.html](http://www.space.com/34092-comet-disintegration-hubble-telescope-photos.html)



Comet 332P/Ikeya-Murakami is breaking apart as it orbits the sun. Images taken by the Hubble Space Telescope captured building-size chunks of debris as they fell behind the main comet body.

September 15, 2016 – Comet 332P/Ikeya-Murakami is breaking apart as it orbits the sun. Images taken by the Hubble Space Telescope captured building-size chunks of debris as they fell behind the main comet body. Building-size chunks of rock were photographed by the Hubble Space Telescope in January as they broke free from a disintegrating comet zooming around the sun. The relatively rare images are providing insight into how these icy space rocks die.

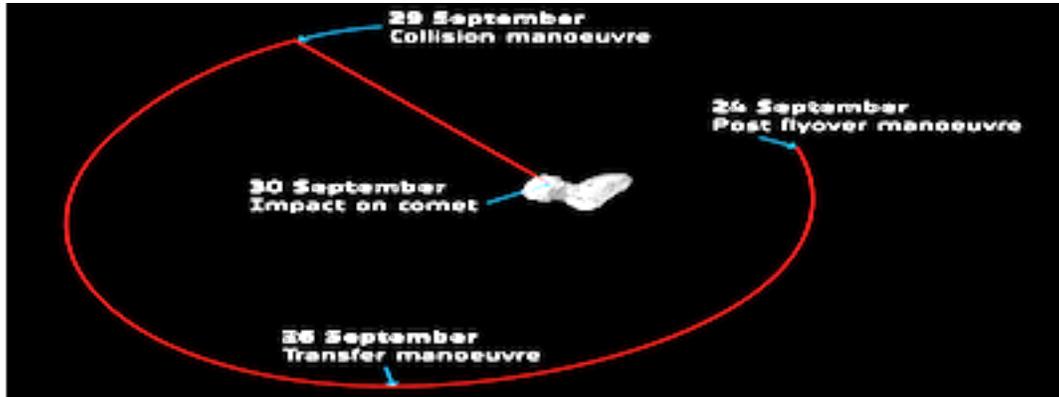
The new images show a large, bright speck of light — the solid core of Comet 332P (short for 332P/Ikeya-Murakami) — trailed by a parade of smaller bluish-white dots. Over the course of three days, those small dots can be seen falling farther behind the comet's main body.

Comet 332P is currently about the length of five football fields, but observations going back to 2010 show that its size has been deteriorating for some time. The comet and its debris trail are visible because they are made partly of ices that reflect sunlight. ##

## Rosetta Spacecraft's Last Move: A Daring Dive Toward Comet Pits

[www.space.com/34082-rosetta-comet-spacecraft-daring-descent.html](http://www.space.com/34082-rosetta-comet-spacecraft-daring-descent.html)

September 15, 2015 – The last-ever maneuver of the European Space Agency's **Rosetta spacecraft** on Sept. 30 will take it toward several active pits on the "head" of Comet 67P/Churyumov-Gerasimenko. Rosetta's descent will take it to a spot next to a 425-ft-wide (130 m) pit informally named Deir el-Medina, which refers to a structure that had a similar appearance in an ancient Egyptian town. Many of Comet 67P's jets originate in pits such as Deir el-Medina.



[Vertical dimension reduced by editor]

The walls of the pits also exhibit intriguing meter-sized lumpy structures called 'goosebumps,' which scientists believe could be the signatures of early 'cometesimals' that assembled to create the comet in the early phases of solar system formation. ##

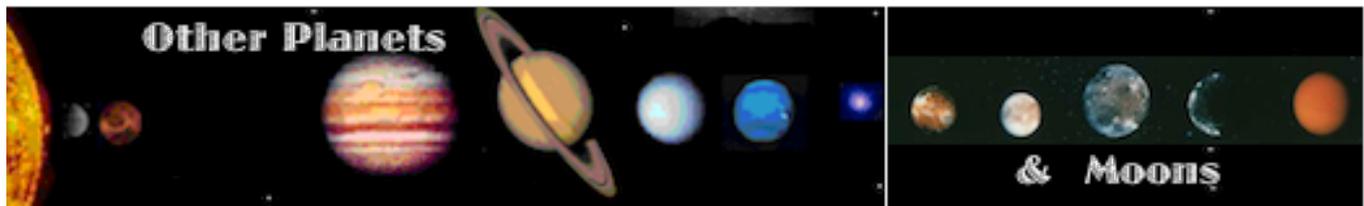
## Rosetta: The end of a space odyssey

<http://phys.org/news/2016-09-rosetta-space-odyssey.html>

[www.space.com/34222-rosetta-probe-s-death-dive-into-comet-67p-visualized.html](http://www.space.com/34222-rosetta-probe-s-death-dive-into-comet-67p-visualized.html)

September 26, 2016 – Europe's trailblazing deep-space comet exploration for clues to the origins of the Solar System ends Friday with the Rosetta orbiter joining robot lab Philae on the iceball's dusty surface for eternity.

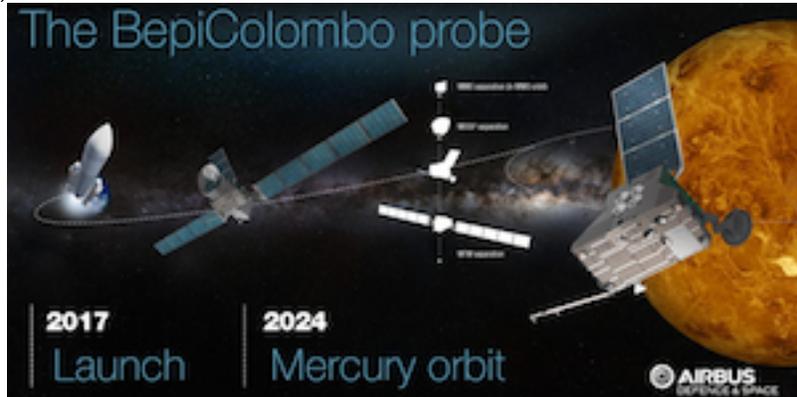
The 1.4-billion-euro (\$1.5-billion), 12-year odyssey will conclude with a last-gasp spurt of science-gathering as Rosetta departs the orbit of comet 67P/Churyumov-Gerasimenko and descends over 14 hours to her final resting place. ##



## MERCURY

### BepiColombo Mission to Mercury on Track for April 2018 Launch

[www.spacedaily.com/reports/BepiColombo\\_Mission\\_to\\_Mercury\\_on\\_Track\\_for\\_April\\_2018\\_Launch\\_999999.html](http://www.spacedaily.com/reports/BepiColombo_Mission_to_Mercury_on_Track_for_April_2018_Launch_999999.html) – July 22, 2016



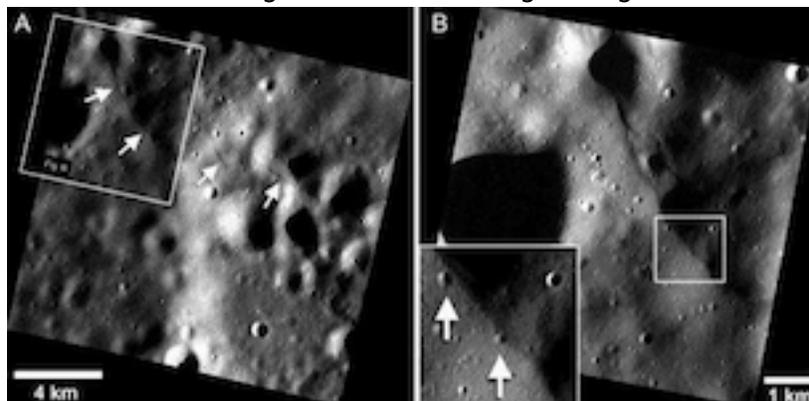
BepiColombo is on track for launch in 2018. Currently scientists are preparing for some final acceptance tests. On the 'Mercury Transport Module' (MTM) they need to finish the installation of some late deliveries and then the module has to undergo a thermal verification and thermal balance test. This is to prove that the thermal shielding of this spacecraft module works as predicted by the models

### Mercury found to be tectonically active

<http://phys.org/news/2016-09-mercury-tectonically.html>

September 26, 2016 – Images acquired by NASA's MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft show geologic features that indicate Mercury is likely still contracting today, joining Earth as a tectonically active planet in our Solar System.

Previously undetected small fault scarps were observed in images collected in the MESSENGER mission's final 18 months in orbit around Mercury. During these last months of the mission, the spacecraft's altitude was lowered allowing the surface to image at higher resolutions before impossible.



A cluster of small lobate scarp thrust faults on Mercury's intercrater plains (~38.90° N, 27.93° E). The longest scarp in the cluster (upper arrows) is ~4.3 km in length.

These small-scale thrust fault scarps are orders of magnitude smaller, only a few kilometers in length and tens of meters of relief, than larger scarps previously known to exist on the surface of

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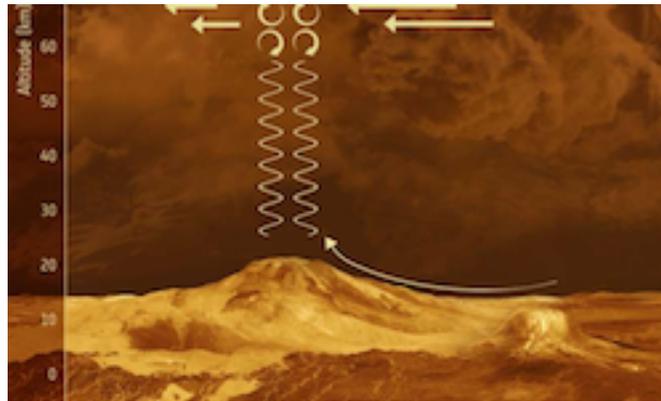
Mercury. Steady meteoroid bombardment quickly degrades and destroys structures this small, indicating that they must have formed relatively recently. They are comparable in size to very young fault scarps identified on the lunar surface attributed to shrinking of the Moon.

The young age of the small scarps means that **Mercury joins Earth as a tectonically active planet in our Solar System**, with new faults likely forming today as Mercury's interior continues to cool.

## VENUS

### What lies beneath: Venus' surface revealed through the clouds

July 18, 2016 – <http://phys.org/news/2016-07-lies-beneath-venus-surface-revealed.html>



Venus is famously hot, due to an extreme greenhouse effect which heats its surface due to temperatures as high as 450°C/840°F. The climate at the surface is oppressive; as well as being hot, the surface environment is dimly lit, due to a thick blanket of cloud which completely envelops the planet. Ground-level winds are slow, pushing their way across the planet at painstaking speeds of about 1 metre per second – no faster than a gentle stroll.

Using observations from ESA's Venus Express satellite, scientists have shown for the first time how weather patterns seen in Venus' thick cloud layers are directly linked to the topography of the surface below.

Rather than acting as a barrier to our observations, Venus' clouds may offer insight into what lies beneath. ##

### Venus Climate Orbiter "AKATSUKI" finishes 1<sup>st</sup> Venus year in orbit

July 28, 2016 – On July 19, Akatsuki celebrated 1st Venus's year anniversary (225 Earth days). Akatsuki keeps working well and continues to gather lots of data. The four cameras aboard the Venus Climate Orbiter "Akatsuki" keep sending down images.

#### Infrared light enables more detailed investigation of Venus.

The probe vehicle of AKATSUKI is in an elliptical orbit, 300 to 80,000 km away from Venus's surface. This wide variation in distance enables comprehensive observations of the planet's meteorological phenomena and of its surface, as well as observations of the atmospheric particles escaping from Venus into space.

It also allows close-up photos of Venus, and observation of the storm winds that blow on the Venusian surface, at speeds that reach 100 m a second – 60 times the speed at which Venus rotates. This phenomenon remains the biggest mystery of Venus, as it cannot be explained meteorologically.

AKATSUKI employs infrared light to observe and elucidate the mysteries surrounding the atmosphere under the clouds and the conditions on the planet's surface.

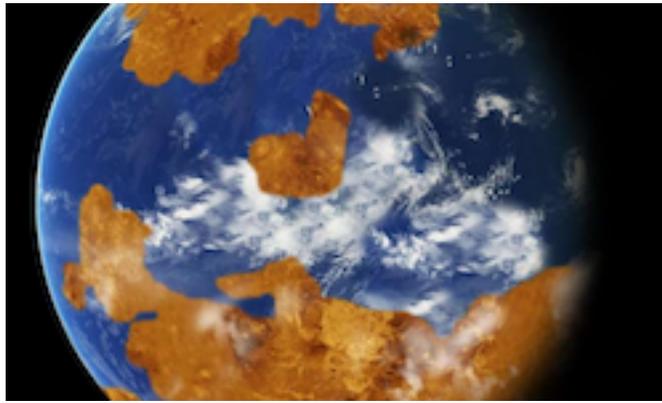
In addition, it has confirmed the presence of active volcanoes and thunder. ##

### NASA climate modeling suggests Venus may have been habitable

August 11, 2016 – <http://phys.org/news/2016-08-nasa-climate-venus-habitable.html>

<http://phys.org/news/2016-08-simulations-venus-life.html>

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Observations suggest Venus may have had water oceans in its distant past. A land-ocean pattern like that above was used in a climate model to show how storm clouds could have shielded ancient Venus from strong sunlight and made the planet habitable. Venus may have had a shallow liquid-water ocean and habitable surface temperatures for up to 2 billion years of its early history, according to computer modeling of the planet's ancient climate by NASA Goddard scientists.

Venus is closer to the sun than Earth and receives far more sunlight. As a result, the planet's early ocean evaporated, water-vapor molecules were broken apart by ultraviolet radiation, and hydrogen escaped to space. With no water left on the surface, carbon dioxide built up in the atmosphere, leading to a so-called runaway greenhouse effect that created present conditions. ##

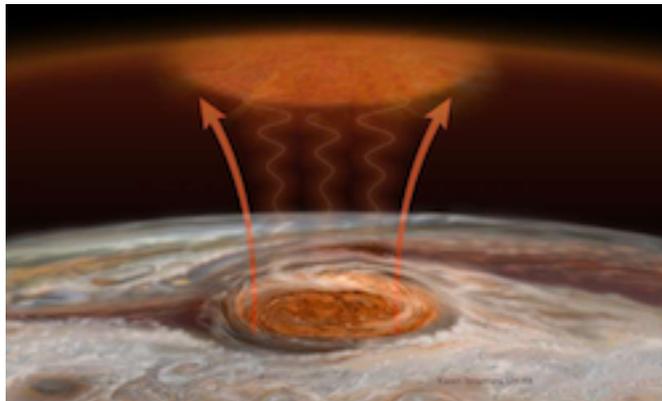
## JUPITER & ITS MOONS

### Jupiter's Great Red Spot is Also Red Hot, Study Shows

July 27, 2016 - [www.space.com/33551-jupiter-heats-up-great-red-spot.html](http://www.space.com/33551-jupiter-heats-up-great-red-spot.html)

### Jupiter's Great Red Spot heats planet's upper Atmosphere

July 27, 2016 - [phys.org/news/2016-07-jupiter-great-red-planet-upper.html](http://phys.org/news/2016-07-jupiter-great-red-planet-upper.html)



The Great Red Spot (GRS) is a massive storm about twice the diameter of Earth that lies in lowest layer of Jupiter's atmosphere. About 497 miles (800 kilometers) above this humongous storm, astronomers measured temperatures reaching about 700 degrees Fahrenheit (about 370 degrees Celsius) higher than normal,

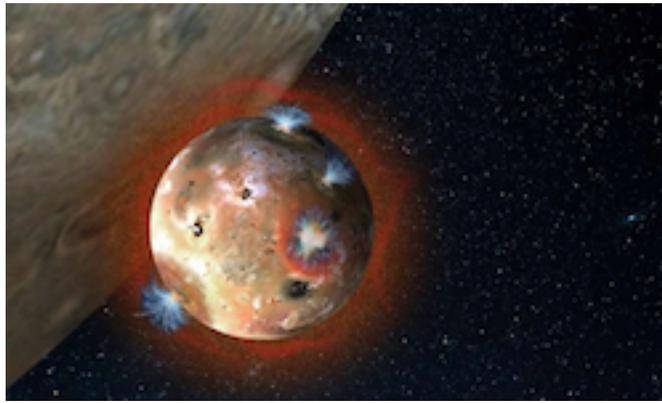
### Space scientists observe Io's atmospheric collapse during eclipse

August 2, 2016 - <http://phys.org/news/2016-08-space-scientists-io-atmospheric-collapse.html>

A Southwest Research Institute-led team has documented atmospheric changes on Io, Jupiter's volcanically active satellite, as it casts its shadow over the moon's surface during daily eclipses.

(Jupiter's 3<sup>rd</sup> largest moon, diameter 1,942 mi (3,636 km) vs. The Moon's diameter 2,160 mi (3,476 km)

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An artist's rendering depicts the atmosphere on Io, Jupiter's volcanic moon, as it collapses during daily eclipses. Credit: Southwest Research Institute

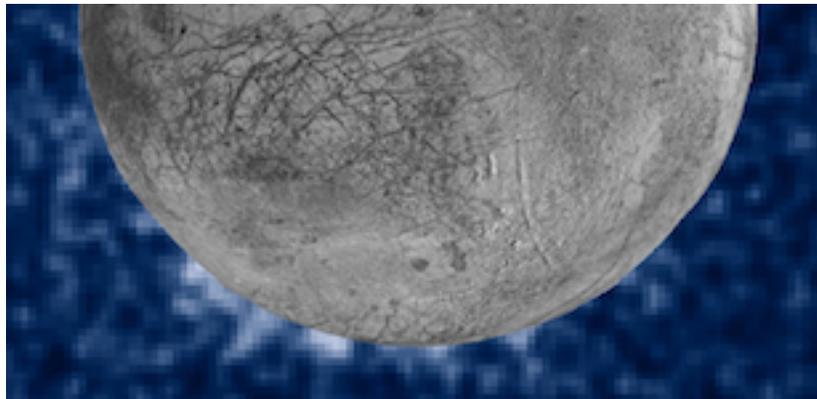
## JUPITER'S MOON EUROPA

### Hubble Space Telescope Spots Possible Water Plumes Erupting on Europa

[www.space.com/34151-nasa-activity-spied-on-europa-but-its-not-aliens.html](http://www.space.com/34151-nasa-activity-spied-on-europa-but-its-not-aliens.html)

[www.nasa.gov/press-release/nasa-s-hubble-spots-possible-water-plumes-erupting-on-jupiters-moon-europa](http://www.nasa.gov/press-release/nasa-s-hubble-spots-possible-water-plumes-erupting-on-jupiters-moon-europa) - [www.space.com/34196-jupiter-moon-europa-giant-water-plumes.html](http://www.space.com/34196-jupiter-moon-europa-giant-water-plumes.html)

September 26, 2016 Press Release:



This composite image shows suspected plumes of water vapor erupting at the 7 o'clock position off the limb of Jupiter's moon Europa. The plumes, photographed by NASA's Hubble's Space Telescope Imaging Spectrograph, were seen in silhouette as the moon passed in front of Jupiter.

Hubble's ultraviolet sensitivity allowed for the features -- rising over 100 miles (160 kilometers) above Europa's icy surface -- to be discerned. The water is believed to come from a subsurface ocean on Europa. The Hubble data were taken on January 26, 2014. The image of Europa, superimposed on the Hubble data, is assembled from data from the Galileo and Voyager missions.



**Editor:** NASA needs to stop twiddling with remote observations, even those from an Europa orbiter, and instead land a probe on one of those rusty colored streaks (where water from the ocean below has reached the surface when and where the ice crust has cracked (all over the place) and do a chemical analysis of the colored material, and be able to identify any organic compounds. ##

## Infographic showing what we know about Europa

<http://www.space.com/34172-europa-subsurface-ocean-what-we-know.html>

## Does Jupiter's Moon Europa Have a Subsurface Ocean? What We Know.

[www.space.com/34172-europa-subsurface-ocean-what-we-know.html](http://www.space.com/34172-europa-subsurface-ocean-what-we-know.html)

September 26, 2016 – There is a lot of indirect evidence for a liquid ocean of some sort.

- One clue is the mass of Europa. When we measure the density, we get a figure close to one [gram per cubic centimeter] and water is the only material like that.
- Another big indicator is the way Europa interacts with Jupiter's magnetic field, as measured by the Galileo probe in the 1990s. The way we know some is liquid was the probe's magnetometer. As Europa went through Jupiter's field the magnetometer saw deflection exactly where you would expect if there were an induced field. The only way to get such an induced field is if there's some substance that is globally connected, and conductive — and only salty water fits the bill. You wouldn't get the same readings with isolated pools of water, like what is found under ice sheets on Earth.
- Slushy water-ice mixtures don't work, either.

### Europa's surface also offers evidence for liquid-water oceans.

- First, spectroscopic measurements have showed that the surface is covered in water ice, and that it is smoother than a cue ball. None of the topography is more than a couple of hundred meters tall.
- That doesn't mean it's flat like a tabletop or frozen lake, though — it's actually quite chaotic and rough, at least at small scales. At the same time, the surface lacks impact craters.
- Given the rate of cratering on all the surrounding moons, Europa's surface doesn't look like it is more than 50 million years old. That means there is some way the planet is getting resurfaced relatively often. If the moon were covered with ice and had only a rock layer underneath it, you'd expect a much older appearing surface. ##

**Editor:** There is other evidence. Europa is covered with "cracks" that are ochre or reddish in color.

[See the image in the post directly above]

This would seem to be frozen ocean water that contains something to give the cracks that color. And the only explanation offered so far (by me, maybe others unknown to me) is that this coloration may be from organic matter in the ocean below, indicating that this ocean supports life forms of some kind.

**These cracks beg for exploration: a lander equipped to analyze and even micro photograph and organic materials or relics of organic organisms that escaped to the surface when the crack in the ice developed.** Yet NASA has no plans we've heard of to check out one of these surface features. Such a probe should be #1 priority - and within the next five years, not put off for irrelevant "budget" problems. PK

## SATURN & ITS MOONS

[In 2017, the Cassini spacecraft will take a suicidal plunge into Saturn, measuring as much as it can about the atmosphere and interior of that planet before disintegrating.]

## Saturn's Moons: Facts About the Ringed Planet's Satellites

June 30, 2016 – [www.space.com/20812-saturn-moons.html](http://www.space.com/20812-saturn-moons.html)

At least 62 moons orbit around Saturn. They come in a variety of sizes and compositions, from almost pure ice to rocky material, as well as a combination of both. Their journeys around the ringed planet range from half an Earth day to just over four Earth years.

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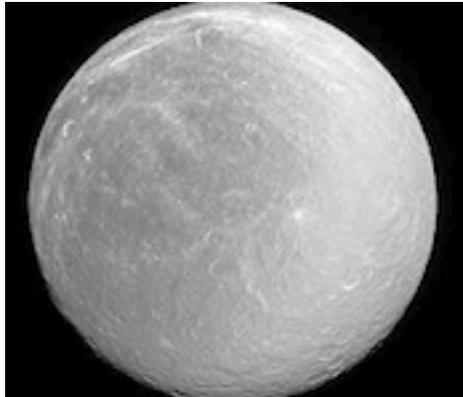
### Two interesting theories

Titan, makes up 96% of the mass orbiting the planet. One theory is that Saturn's system may have originally housed two such moons, but the second broke up, creating the debris that formed the rings and smaller, inner moons.

Another theory suggests that the system originally housed several large moons, similar to Jupiter's Galilean moons, but two fused into Titan. The violent collision could have scattered the debris that would have later drawn together into the smaller moons

### Rhea Shines Brightly About Saturn

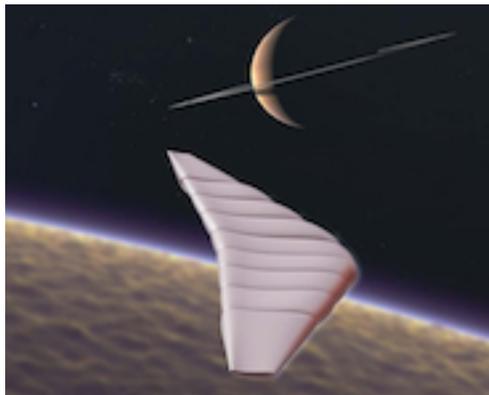
August 5, 2016 – [www.spacedaily.com/reports/Rhea\\_Shines\\_Brightly\\_About\\_Saturn\\_999.html](http://www.spacedaily.com/reports/Rhea_Shines_Brightly_About_Saturn_999.html)



Rhea 949 mi (1,527 km) across, is Saturn's second largest moon after Titan. Its ancient surface is one of the most heavily cratered of all of Saturn's moons. Subtle albedo variations across the disk of Rhea hint at past geologic activity. ##

### Sirens of Titan: Flying Aerobot Drone Could Soar Over Saturn Moon

June 30 2016 – [www.space.com/33412-nasa-aerobot-drone-saturn-moon-titan.html](http://www.space.com/33412-nasa-aerobot-drone-saturn-moon-titan.html)



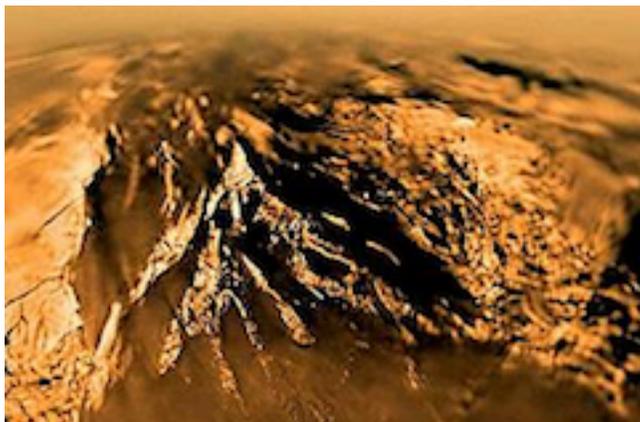
Artist's impression of a winged vehicle entering the atmosphere of Titan

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NASA is moving forward with an early-stage technology study to send a drone to its moon Titan, awarding a Small Business Innovation Research (SBIR) Phase 1 contract for **Global Aerospace Corp.** and **Northrop Grumman Aerospace Systems** to create a vehicle known as the “Titan Winged Aerobot” built to explore Titan and prepare a prototype for testing on Earth. SBIR Phase 1 contracts last six months and are worth up to \$125,000,

## Chemical trail on Titan may be key to prebiotic conditions

[www.spacedaily.com/reports/Chemical\\_trail\\_on\\_Titan\\_may\\_be\\_key\\_to\\_prebiotic\\_conditions\\_999.html](http://www.spacedaily.com/reports/Chemical_trail_on_Titan_may_be_key_to_prebiotic_conditions_999.html)



July 11, 2016 – An image of Titan's surface, as taken by the European Space Agency's Huygens probe as it plunged through the moon's thick, orange-brown atmosphere on Jan. 14, 2005.

Today, scientists have chemical evidence that suggests prebiotic conditions may exist there

## Methane-Filled Canyons Line Titan's Surface

[www.spacedaily.com/reports/Methane\\_Filled\\_Canyons\\_Line\\_Titans\\_Surface\\_999.html](http://www.spacedaily.com/reports/Methane_Filled_Canyons_Line_Titans_Surface_999.html)



A view of Titan's northern pole reveals many hydrocarbon lakes and seas.

Titan is the only other world other than Earth, where erosion actively etches its surface.

August 12, 2016 – Liquid methane-filled canyons hundreds of meters deep with walls as steep as ski slopes etch the surface of Titan. New Cassini radar observations of Titan's north pole depict cavernous gorges a little less than a kilometer (less than half a mile) wide with walls up to 570 m (1,870 ft) tall – about 30 meters (98 feet) higher than New York's Freedom Tower. The eight canyons branch off from Vid Flumina, a more than 400-k (249-mi) long river flowing into Titan's second-largest sea, Ligeia Mare. The new data confirm the canyons are filled with flowing methane – a feature researchers had suspected but not directly observed. ##

## Titan's Dunes and Other Features Emerge in New Images

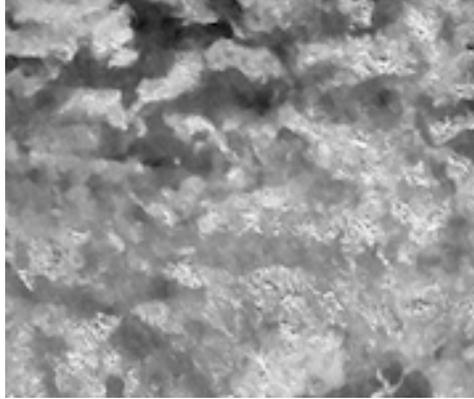
[www.spacedaily.com/reports/Titans\\_Dunes\\_and\\_Other\\_Features\\_Emerge\\_in\\_New\\_Images\\_999.html](http://www.spacedaily.com/reports/Titans_Dunes_and_Other_Features_Emerge_in_New_Images_999.html)

September 8, 2016 – Cassini obtained the views during a close flyby of Titan on July 25, when the craft came as close as 607 mi (976 km) from the second largest moon in the Solar System (after Jupiter's

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Ganymede). Cassini's radar instrument is able to penetrate the dense, global haze that surrounds Titan, to reveal fine details on the surface.

One of the new views shows long, linear dunes, thought to be comprised of grains derived from hydrocarbons that have settled out of Titan's atmosphere. Dunes of this sort encircle most of Titan's equator. Scientists can use the dunes to learn about winds, the sands they're composed of, and highs and lows in the landscape.



This synthetic-aperture radar (SAR) image was obtained by NASA's Cassini spacecraft on July 25, 2016, during its "T-121" pass over Titan's southern latitudes. ##

## Nasa scientists find 'impossible' cloud on Titan—again

<http://phys.org/news/2016-09-nasa-scientists-impossible-cloud-titanagain.html>

[www.spacedaily.com/reports/NASA\\_Scientists\\_Find\\_Impossible\\_Cloud\\_on\\_Titan\\_Again\\_999.html](http://www.spacedaily.com/reports/NASA_Scientists_Find_Impossible_Cloud_on_Titan_Again_999.html)

[www.space.com/34161-impossible-cloud-on-saturn-moon-titan.html](http://www.space.com/34161-impossible-cloud-on-saturn-moon-titan.html)

September 21, 2016 – The puzzling appearance of an ice cloud seemingly out of thin air has prompted NASA scientists to suggest that a different process than previously thought—possibly similar to one seen over Earth's poles—could be forming clouds on Saturn's moon Titan.

Located in Titan's stratosphere, the cloud is made of a compound of carbon and nitrogen known as dicyanoacetylene (C<sub>4</sub>N<sub>2</sub>), an ingredient in the chemical cocktail that colors the giant moon's hazy, brownish-orange atmosphere.

Decades ago, the infrared instrument on NASA's Voyager 1 spacecraft spotted an ice cloud just like this one on Titan. What has puzzled scientists ever since is this: they detected less than 1 percent of the dicyanoacetylene gas needed for the cloud to condense. The appearance of this ice cloud goes against everything we know about the way clouds form on Titan. ##

## URANUS & ITS MOONS

### Moons of Uranus: Facts About the Tilted Planet's Satellites

June 20, 2016 – [www.space.com/22201-uranus-moons.html](http://www.space.com/22201-uranus-moons.html)

Uranus has 27 known moons, most of which we didn't discover until the space age. They range from Titania, 981 miles (1,579 km) in diameter, to tiny Cupid, only 11 miles (18 km) in diameter. All satellites of Uranus are named for characters in William Shakespeare plays or characters from Alexander Pope's "Rape of the Lock,"

We knew of five moons before Voyager 2 launched in 1977. The probe found an additional 10 when it swung by the system in 1986.

No spacecraft has gone to Uranus since then, but astronomers have found new moons with the aid of generally improving telescope technology and techniques. The latest discoveries — Mab, Cupid, AND Margaret — were confirmed in 2003.

**Umbriel**, the darkest of Uranus' big moons: in Voyager 2's quick fly-by, scientists could not figure out how the surface got so dark, or why there is a bright ring on Umbriel's surface that is 90 miles (140 km) in diameter.

**Ariel** has the youngest and brightest known surface among the moons. This could be due to meteorite hits, as well as possible geologic activity — among its features are grabens, or valleys surrounded by faults. Voyager 2 detected a silicate rock and water ice composition on this moon, with hints of carbon dioxide.

The last find before the space age was perhaps the most bizarre moon of all — **Miranda**, which appears to be a jumble of disconnected features. It's unclear what made the mashed-up surface. Perhaps a huge meteorite blew the moon apart and it reassembled, or smaller meteorites melted the surface and caused slush to flow and freeze again. ##

## NEPTUNE & ITS MOONS

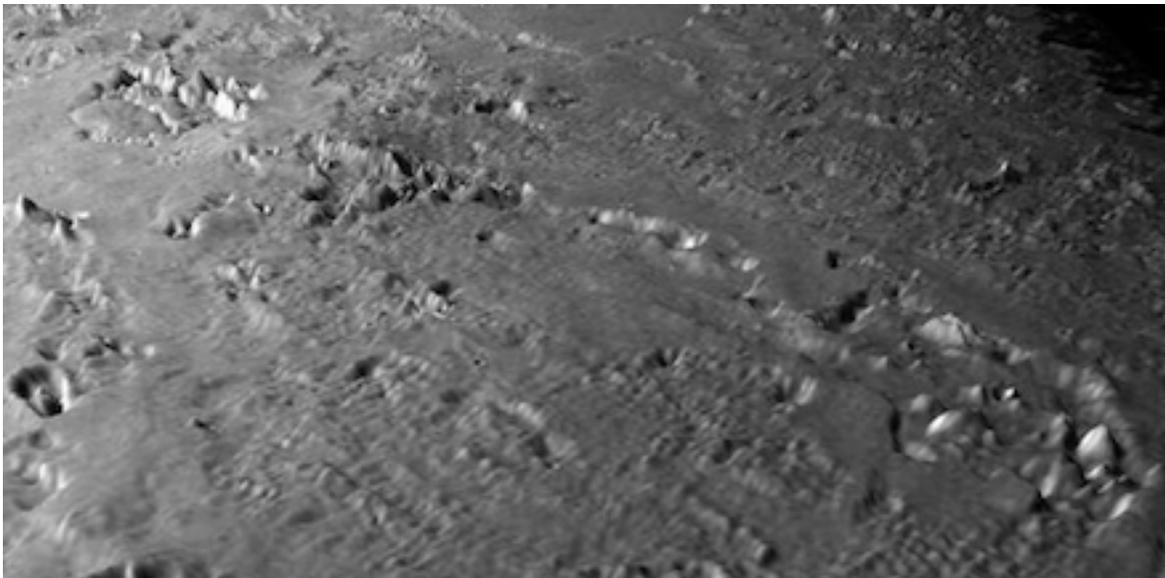
### Neptune's Moons: 14 Discovered So Far

June 30, 2016 - [www.space.com/22222-neptunes-moons.html](http://www.space.com/22222-neptunes-moons.html)

Neptune, the farthest planet from the sun, has 14 known moons. Almost half of the discoveries took place decades after NASA's Voyager 2 spacecraft swung by the planet and its system, demonstrating just how far telescope technology has progressed. (One moon was also spotted in 2013 after being lost for nearly 25 years.

### Triton: Neptune's Odd Moon

June 30, 2016 - [www.space.com/22223-triton-moon.html](http://www.space.com/22223-triton-moon.html)



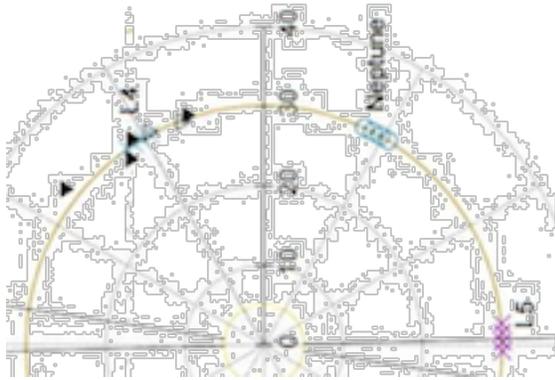
[Editor. I watched Voyager 2's pass over Triton live back in 1989, and my impression was that its surface looked like that of a cantalope.]

To NASA's knowledge, Triton is the **only moon** in the solar system that orbits in a direction **opposite to the rotation of its planet**. Additionally, its surface is a study of contrasts, with smooth plains appearing to be right next to cratered surfaces.

No spacecraft has gone to Neptune since the 1980s, but telescopes are capturing new data on Triton from the ground. A notable recent find was discovering seasons on this moon. ##

### Astronomers discover five new Neptune trojans

<http://phys.org/news/2016-09-astronomers-neptune-trojans.html>



The spatial distribution of all PS1 detected Trojans. The solid triangles are the newly discovered Neptune Trojans, and open triangles are the known ones detected by PS1. The positions of Neptune Trojans correspond to their first detections

## PLUTO-CHARON & THEIR MOONS

### X-ray detection sheds new light on Pluto

<http://phys.org/news/2016-09-x-ray-pluto.html>

September 14 2016 – Scientists using NASA's Chandra X-ray Observatory have made the first detections of X-rays from Pluto. These observations offer new insight into the space environment surrounding the largest and best-known object in the solar system's outermost regions.

Scientists using NASA's Chandra X-ray Observatory have made the first detections of X-rays from Pluto. These observations offer new insight into the space environment surrounding the largest and best-known object in the solar system's outermost regions. Pluto is interacting with the solar wind in an unexpected and energetic fashion. ##

### Pluto 'paints' its largest moon Charon red

<http://phys.org/news/2016-09-pluto-largest-moon-charon-red.html>

September 14, 2016 – In June 2015, when the cameras on NASA's approaching New Horizons spacecraft first spotted the large reddish polar region on Pluto's largest moon, Charon, mission scientists knew two things: they'd never seen anything like it elsewhere in our solar system, and they couldn't wait to get the story behind it.

Scientists now think they've solved the mystery. Charon's polar coloring comes from Pluto itself – as methane gas that escapes from Pluto's atmosphere and becomes "trapped" by the moon's gravity and freezes to the cold, icy surface at Charon's pole. This is followed by chemical processing by ultraviolet light from the sun that transforms the methane into heavier hydrocarbons and eventually into reddish organic materials called tholins.



NASA's New Horizons spacecraft captured this high-resolution, enhanced color view of Pluto's largest moon, Charon, just before closest approach on July 14, 2015. The image combines blue, red and infrared images taken by the spacecraft's camera.

## Shedding light on Pluto's glaciers

<http://phys.org/news/2016-09-pluto-glaciers.html>

September 18, 2016 – What is the origin of the large heart-shaped nitrogen glacier revealed in 2015 on Pluto by the New Horizons spacecraft? Two researchers show that Pluto's peculiar insolation and atmosphere favor nitrogen condensation near the equator, in the lower altitude regions, leading to an accumulation of ice at the bottom of Sputnik Planum, a vast topographic basin. Through their simulations, they also explain the surface distribution and atmospheric abundance of other types of volatiles observed on Pluto.

Pluto is a glaciologists' paradise. Among the types of ice covering its surface, nitrogen is the most volatile: when it sublimates at  $-235\text{ }^{\circ}\text{C}$ , it forms a thin atmosphere in equilibrium with the ice reservoir at the surface. One unexpected observations from New Horizons, showed that this reservoir of solid nitrogen is extremely massive, and mostly contained in "Sputnik Planum." ##

## Pluto's 'heart' sheds light on a possible buried ocean

<http://phys.org/news/2016-09-pluto-heart-ocean.html>

[www.space.com/34179-plutos-heart-hints-at-deep-underground-ocean.html](http://www.space.com/34179-plutos-heart-hints-at-deep-underground-ocean.html)

September 23, 2016 – Ever since NASA's New Horizons spacecraft flew by Pluto last year, evidence has been mounting that the dwarf planet may have a liquid ocean beneath its icy shell. Now, by modeling the impact dynamics that created a massive crater on Pluto's surface, a team of researchers has made a new estimate of how thick that liquid layer might be. Pluto's famous "heart," half of which was created by an ancient impact, offers clues about a possible subsurface ocean.



The study finds a high likelihood that there's more than 100 kilometers of liquid water beneath Pluto's surface. The research also offers a clue about the composition of that ocean, suggesting that it likely has a salt content similar to that of the Dead Sea.

Thermal models of Pluto's interior and tectonic evidence found on the surface suggest that an ocean may exist, but it's not easy to infer its size or anything else about it. But scientists have been able to put some constraints on its thickness and get some clues about composition. ##

## BEYOND PLUTO-CHARON

### It's Official! NASA Pluto Probe to Fly by Another Object in 2019

July 1, 2016 – [www.space.com/33332-new-horizons-pluto-probe-mission-extension.html](http://www.space.com/33332-new-horizons-pluto-probe-mission-extension.html)

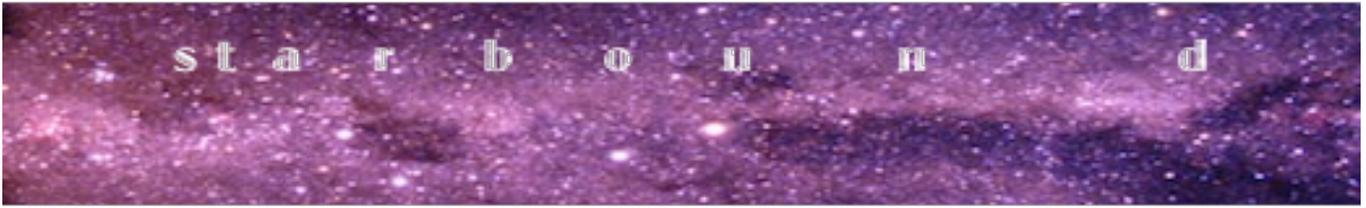
NASA has approved a mission extension for New Horizons, which performed the first-ever flyby of the Pluto-Charon binary planet system in July 2015. The spacecraft is now set for a Jan. 1, 2019 flyby of a small object called 2014 MU69, which lies about 1 billion miles (1.6 billion kilometers) beyond Pluto in the dark and frigid Kuiper Belt.##

### New Dwarf Planet Discovered Far Beyond Pluto's Orbit

July 11, 2016 – <http://www.space.com/33387-dwarf-planet-discovery-2015-rr245.html>

Astronomers have discovered another dwarf planet in the Kuiper Belt, beyond Neptune. This newfound world, dubbed 2015 RR245, is much more distant than Pluto, orbiting the sun once every 700 Earth years. (Pluto completes one lap around the sun every 248 Earth years.) ##

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

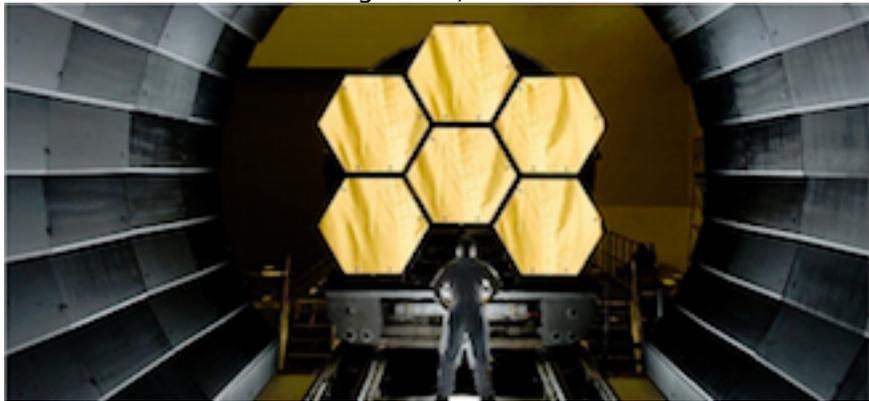


## EARTHBOUND TELESCOPES

### Commercial Space to Smash the Astronomy 'Funding Wall'?

[www.space.com/33694-could-commercial-space-solve-the-astronomy-funding-wall.html](http://www.space.com/33694-could-commercial-space-solve-the-astronomy-funding-wall.html)

August 10, 2016 -



A mirror inspection of the James Webb Space Telescope, scheduled to launch in 2018

What's happening in our universe? In the 400 years since we first started using telescopes, we've been trying to answer this question. The past two decades alone have been dizzying: Planets found outside the solar system, a universe accelerating in its expansion, and hints of the mysterious dark energy and dark matter that make up most of the universe, to name a handful of historic discoveries. But to see further, we often need to spend **big**.

The \$9 billion James Webb Space Telescope will launch in 2018, to probe planetary atmospheres and to look back at the universe's beginnings. What will come next? Looking a bit ahead, the astronomy organization AURA suggests a "High Definition Space Telescope" to launch in 2035, an observatory double Webb's size. But would this would be paid for? ##

### China begins operating the world's Largest Radio Telescope

<http://phys.org/news/2016-09-china-world-largest-radio-telescope.html>



The new radio telescope is nestled in a natural basin within a stunning landscape of lush green karst formations in southern Guizhou province. It took five years and \$180 million to complete. ##

## STARBOUND SPACECRAFT

## First test of Breakthrough Starshot interstellar probe highlights likely damage due to gas and dust

<http://phys.org/news/2016-08-breakthrough-starshot-interstellar-probe-highlights.html>

August 25, 2016 – A small team of researchers at Harvard University who are part of the Breakthrough Starshot team has been testing the likely damage to an interstellar spacecraft traveling at approximately one-fifth the speed of light as it makes its way to the Alpha Centauri star system. As they note in a paper describing their testing and results, which was uploaded to the arXiv preprint server, such damage could be catastrophic, **but they believe they have a solution.** ##

## EXO-PLANETS

## d evidence of water clouds in first spectrum of coldest brown dwarf

July 5, 2016 – <http://phys.org/news/2016-07-astronomers-evidence-clouds-spectrum-coldest.html>

Since its detection in 2014, the brown dwarf known as **WISE 0855** has fascinated astronomers. Only **7.2 light-years from Earth**, it is the **coldest known object** outside of our solar system and is just barely visible at infrared wavelengths with the largest ground-based telescopes.

A team led by astronomers at UC Santa Cruz has succeeded in obtaining an infrared spectrum of WISE 0855 using the Gemini North telescope in Hawaii, providing the first details of the object's composition and chemistry. Among the findings is strong evidence for the existence of **clouds of water or water ice, the first such clouds detected outside of our solar system.** ##

## An equation to quantify the origins of life on other planets

July 5, 2016 – <http://phys.org/news/2016-07-equation-quantify-life-planets.html>

A pair of researchers, one with the Columbia Astrobiology Center in New York, the other with the University of Glasgow in the U.K. has come up with a mathematical equation that when solved is meant to offer a means for estimating how often life begins on other planets.

## SETI Seeks Ideas to Hunt Strange Alien Lifeforms

July 14, 2016 – [www.space.com/33424-seti-seeks-ideas-to-hunt-strange-alien-lifeforms.html](http://www.space.com/33424-seti-seeks-ideas-to-hunt-strange-alien-lifeforms.html)



The SETI Institute's Allen Telescope Array in California seeks out radio transmissions from hypothetical aliens. Is there another way?

We now know the Earth is in the suburbs of the Milky Way, and our solar system is only special because we live in it, but this series of demotions shows us one thing: it's easy to project our image on to the universe. This is especially true when searching for life. Because there is only one case of life as we know it — life on Earth — it's easiest to look for life like ours. But in reality our kind of life may not be the most common type to look for after all. ##

## A star's birth holds early clues to life potential

July 25, 2016 - <http://phys.org/news/2016-07-star-birth-early-clues-life.html>

Our solar system began as a cloud of gas and dust. Over time, gravity slowly pulled these bits together into the Sun and planets we recognize today. While not every system is friendly to life, astronomers want to piece together how these systems are formed.

A challenge to this research is the opacity of dust clouds to optical wavelengths (the ones that humans can see). So, astronomers are experimenting with different wavelengths, such as infrared light, to better see the center of dense dust clouds, where young stars typically form.

## NASA's next planet hunter will look closer to home

July 28, 2016 - <http://phys.org/news/2016-07-nasa-planet-hunter-closer-home.html>

As the search for life on distant planets heats up, NASA's Transiting Exoplanet Survey Satellite (TESS) is bringing this hunt closer to home. Launching in 2017-2018, TESS will identify planets orbiting the brightest stars just outside our solar system using what's known as the transit method.

## The role of Magnetic Fields in star formation

July 29, 2016 - <http://phys.org/news/2016-07-role-magnetic-fields-star-formation.html>

The star forming molecular clump W43-MM1 is very massive and dense, containing about 2100 solar masses of material in a region only one-third of a light year across (for comparison, the nearest star to the Sun is a bit over four light years away).

## Is Earthly life premature from a cosmic perspective?

August 1, 2016 - <http://phys.org/news/2016-08-earthly-life-premature-cosmic-perspective.html>

The universe is 13.8 billion years old, while our planet formed just 4.5 billion years ago. Some scientists think this time gap means that life on other planets could be billions of years older than ours. However, new theoretical work suggests that present-day life is actually premature from a cosmic perspective. ##

## Team catalogs most likely 'second-Earth' candidates

August 3, 2016 - <http://phys.org/news/2016-08-team-second-earth-candidates.html>

An international team of researchers has pinpointed which of the more than 4,000 exoplanets discovered by NASA's Kepler mission are most likely to be similar to our rocky home. The research, detailed in an article to be published in the *Astrophysical Journal*, outlines **216 Kepler planets located within the "habitable zone"**—the area around a star in which a planet's surface could hold liquid water. Of those, they list **20 that are the best candidates to be habitable rocky planets like Earth.** ##

## Bacteria Could Aid Search for Creatures On Other Planets

August 9, 2016 - [www.space.com/33683-bacteria-could-aid-alien-life-search.html](http://www.space.com/33683-bacteria-could-aid-alien-life-search.html)

Could there be a way to find bacterial structures on another planet? And if so, how important might these bacteria be in making a planet life-friendly? These are some of the questions that could be answered through studies on **stromatolites**, which are mounds of calcium-carbonate rock that are built up through lime-secreting cyanobacteria (bacteria that use photosynthesis for energy). ##

## "Venus-like" exoplanet might have oxygen atmosphere, but not life

[www.spacedaily.com/reports/Venus like Exoplanet Might Have Oxygen Atmosphere but Not Life 999.html](http://www.spacedaily.com/reports/Venus_like_Exoplanet_Might_Have_Oxygen_Atmosphere_but_Not_Life_999.html)

August 19, 2016 - The distant planet GJ 1132b intrigued astronomers when it was discovered last year. Located just 39 light-years from Earth, it might have an atmosphere despite being baked to a temperature of around 450 degrees Fahrenheit. But would that atmosphere be thick and soupy or thin and wispy? New research suggests the latter is much more likely.

## A new “Goldilocks” requirement for habitable planets

August 19, 20–16 – <http://phys.org/news/2016-08-goldilocks-habitable-planets.html>

A new study suggests a planet must start with an internal temperature that is "just right" in order to support life. For decades, it has been thought that the key factor in determining whether a planet can support life was its distance from its sun. In our solar system, for instance, Venus is too close to the sun and Mars is too far, but Earth is just right. That distance is what scientists refer to as the “habitable zone” or the “Goldilocks zone.”

It also was thought that planets were able to self-regulate their internal temperature via mantle convection—the underground shifting of rocks caused by internal heating and cooling. A planet might start out too cold or too hot, but it would eventually settle into the right temperature.

A new study, appearing in the journal *Science Advances* on Aug. 19, suggests that **simply being in the habitable zone isn't sufficient to support life. A planet also must start with an internal temperature that is just right.** ##

## Hubble finds planet orbiting pair of stars (like “Tatooine”)

<http://phys.org/news/2016-09-hubble-planet-orbiting-pair-stars.html>  
[www.space.com/34159-alien-planet-has-2-suns-instead-of-1.html](http://www.space.com/34159-alien-planet-has-2-suns-instead-of-1.html)

September 22, 2016 – Astronomers using NASA's Hubble Space Telescope, and a trick of nature, have confirmed the existence of a planet orbiting two stars in the system OGLE-2007-BLG-349, located 8,000 light-years away towards the center of our galaxy.

The planet orbits roughly 300 million miles from the stellar duo, about the distance from the asteroid belt to our sun. It completes an orbit around both stars roughly every seven years. The two red dwarf stars are a mere 7 million miles apart, or 14 times the diameter of the moon's orbit around Earth.

The Hubble observations represent the first time such a three-body system has been confirmed using the gravitational microlensing technique. ##

## EXO-PLANETS CONTACT

### Stephen Hawking worried about threat posed by our alien overlords

[www.aol.com/article/news/2016/09/22/stephen-hawking-is-worried-about-the-threat-posed-by-our-alien-o/21477446/](http://www.aol.com/article/news/2016/09/22/stephen-hawking-is-worried-about-the-threat-posed-by-our-alien-o/21477446/)  
[www.space.com/34184-stephen-hawking-afraid-alien-civilizations.html](http://www.space.com/34184-stephen-hawking-afraid-alien-civilizations.html)

September 22, 2016 – In his new half-hour program, 'Stephen Hawking's Favorite Places,' the famed theoretical physicist warns that announcing our presence to alien civilizations, particularly those that could be more technologically advanced than we are, is probably a bad idea.

Gliese 832C is 'super-Earth' only 16 light-years away. It's the sort of world that Hawking hopes to scan for alien signals using all the advanced audio-gathering radio telescopes we can get our hands on.

But if we find intelligent life, Hawking isn't so sure it's going to be all that welcoming.

"If intelligent life has evolved (on Gliese 832c), we should be able to hear it. One day we might receive a signal from a planet like this, but we should be wary of answering back. Meeting an advanced civilization could be like Native Americans encountering Columbus. That didn't turn out so well." ##

#### More information:

[https://en.wikipedia.org/wiki/Gliese\\_832\\_c](https://en.wikipedia.org/wiki/Gliese_832_c)

**Gliese 832 c** (also known as **Gl 832 c** or **GJ 832 c**) is an [extrasolar planet](#) located approximately 16 light years away in the constellation Grus, orbiting the star Gliese 832, a red dwarf star. The planet has an **Earth similarity Index of 0.81**, one of the highest Earth Similarity Indices for any known extrasolar planet. It is in its star's habitable zone.

<http://phl.upr.edu/press-releases/gliese832>

“A Nearby Super-Earth with the Right Temperature but Extreme Seasons: Gliese 832 c has an orbital period of 36 days and a mass at least five times that of Earth's. It receives about the same average energy as Earth does from the Sun. The planet might have Earth-like temperatures, albeit with large seasonal shifts, given a similar terrestrial atmosphere. A denser atmosphere, something expected for Super-Earths, could easily make this planet too hot for life and a “Super-Venus” instead.

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

**Editor:** Communication - at the speed of light is one thing. Finding a way to interfere with another civilization is quite something else. Of course, "they" could "preach" to us. But at the speed of light getting a response will take a minimum of 32 years (message sent and received to reply sent and received.) And what would they have to gain? We shouldn't worry about it.

The chances of finding an Earthlike planet that not only has life, but life at our stage of evolution, with "contemporary civilizations" at a distance where sub-light travel between Earth and the neighbor world in either direction is feasible, is extremely small. #

## [BLOCKBUSTER NEWS – Report of the decade!]

### Scientists unveil new Earth-like planet around the very closest star, Proxima Centauri

August 12, 2016 – <http://phys.org/news/2016-08-scientists-unveil-earth-like-planet.html>

[www.space.com/33751-earth-like-planet-proxima-centauri.html](http://www.space.com/33751-earth-like-planet-proxima-centauri.html)

[www.universetoday.com/130276/earth-like-planet-around-proxima-centauri-discovered/](http://www.universetoday.com/130276/earth-like-planet-around-proxima-centauri-discovered/)

August 18 – [www.space.com/33780-could-proxima-centauri-be-our-interstellar-getaway.html](http://www.space.com/33780-could-proxima-centauri-be-our-interstellar-getaway.html)

August 24, 2016 – [www.space.com/33834-discovery-of-planet-proxima-b.html](http://www.space.com/33834-discovery-of-planet-proxima-b.html)

[www.space.com/33825-earthlike-planet-proxima-b-discovery-in-pictures.html](http://www.space.com/33825-earthlike-planet-proxima-b-discovery-in-pictures.html)

Scientists are preparing to unveil a new planet in our galactic neighbourhood which is "believed to be Earth-like" and that orbits its star at a distance that could favour life.

The exoplanet orbits a well-investigated star called Proxima Centauri, part of the Alpha Centauri star system. The still nameless planet is believed to be Earth-like and orbits at a distance to Proxima Centauri that could allow it to have **liquid water** on its surface—an important requirement for the emergence of life. The European Southern Observatory is to announce the finding at the end of August.

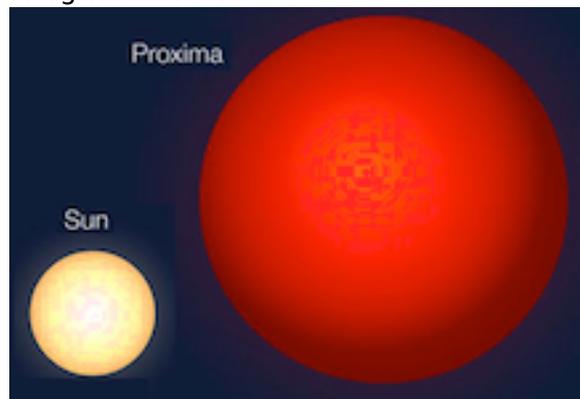
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"Never before have scientists discovered a second Earth that is so close by,"

"To have an exoplanet with any Earth-like qualities so close to the solar system would be an incredible stroke of luck."

"The discovery of a habitable planet orbiting Proxima Centauri could have a profound impact on humanity's interstellar future,"

"Considering that humanity's only bona fide interstellar probe, Voyager 1, has been travelling for almost 39 years and it has only just left our sun's heliopause, sending any kind of probe even to our neighboring star would require transformative propulsion technologies that are at least 50–100 years away at the current rate of technological innovation."



The above graphic shows Proxima's "apparent size" as seen from the newly discovered planet, (96' or 1.5°) In comparison to the Sun's "apparent size" [32' or 0.5°) as seen from Earth.

**About Proxima Centauri:** [https://en.wikipedia.org/wiki/Proxima\\_Centauri](https://en.wikipedia.org/wiki/Proxima_Centauri) {abridged}

**Proxima Centauri** (Latin, meaning "nearest [star] of Centaurus) is a red dwarf, a small low-mass star, about 4.22 light years from the Sun (while the twin stars of Alpha Centauri are about 4.37 light-years

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away) in the constellation Centaurus. It was discovered in 1915, and is the nearest known star to the Sun,<sup>[13]</sup> although it is too faint to be seen with the naked eye, with an apparent magnitude of 11.05. Its distance to the 2nd- and 3rd-nearest stars, which form the bright binary **Alpha Centauri**, is about 86.5 light days). Proxima Centauri is very likely part of a triple star system with Alpha Centauri A and B, but its orbital period around the brighter pair may be greater than 500,000 years. .

“**Ixion\*** (Alpha Centauri A) a little brighter than the Sun, and **Nephthele\*** (Alpha Centauri B) a little dimmer, would appear together in a fixed area of the sky of the newly discovered planet, from 3–10 arc minutes apart at best, seasonally dominating the heavens,

{**Ixion and Nephthele**, the King and Queen of the Centaurs in mythology, are names we had proposed that the Astronomy world should adopt, in an article originally appearing in MMM #44, April 1991 - PK}

“If there is ever to be a stepping stone to human interstellar excursions, this is it!”

But let's wait till we have confirmation, and more details about this closest “exo-Earth.” - PK

### Comment from Poyekhali! Vamos

“The discovery of a Proxima system is only momentous if we mount an expedition there that leaves behind a self-sustaining chunk of our civilization. “

“Reducing transit duration matters far less than shortening time until launch, for the fast ship which never leaves port achieves nothing.”

## What do aliens look like? The clue is in evolution

August 19, 2016 – <http://phys.org/news/2016-08-aliens-clue-evolution.html>

Speculating about what aliens look like has kept children, film producers and scientists amused for decades. If they exist, will extra terrestrials turn out to look similar to us, or might they take a form beyond our wildest imaginings? The answer to this question really depends on how we think evolution works at the deepest level.

At present, the only life forms we can study are here on Earth. These had a single origin around 3.5 billion years ago, but this common ancestor gave rise to perhaps 20m living species of animals alone. These have bodies organised according to c.30 different body plans in major groups called phyla.

But when animals first diversified some 542m or more years ago in the Cambrian “explosion”, there may have been an even greater diversity of fundamental body plans. ##

## A better way to learn if an Alien Planets has “the Right Stuff”

[www.spacedaily.com/reports/A\\_better\\_way\\_to\\_learn\\_if\\_Alien\\_Planets\\_have\\_the\\_Right\\_Stuff\\_999.html](http://www.spacedaily.com/reports/A_better_way_to_learn_if_Alien_Planets_have_the_Right_Stuff_999.html)  
<http://phys.org/news/2016-08-alien-planets.html>

August 25, 2016 – A new method for analyzing the chemical composition of stars may help scientists winnow the search for Earth 2.0, a computational modeling technique that gives a clearer sense of the chemistry of stars, revealing the conditions present when their planets formed. The system creates a new way to assess the habitability and biological evolution possibilities of planets outside our solar system.

The technique has been used previously to determine temperature, surface gravity, rotational speed, and chemical composition information for 1,600 stars, based on 15 elements found within those stars. The new study looks at roughly 800 stars, focusing on their ratio of carbon to oxygen, and magnesium to silicon. **Understanding the makeup of stars helps researchers understand the planets in orbit around them**, by getting a look at the primordial materials that made these planets. Knowing what materials they started with leads to so much else.

They found that if a star has a carbon/oxygen ratio similar to or lower than that of our own Sun, its planets have mineralogy dominated by the magnesium/silicon ratio.

**About 60% of the stars in the study have magnesium/silicon ratios that would produce Earth-like compositions;** 40% of the stars have silicate-heavy interiors. ##

## Know thy star, know thy planet

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

<http://phys.org/news/2016-09-thy-star-planet.html>

September 14, 2016 – When it comes to exoplanets, astronomers have realized that they only know the properties of the planets they discover as well as they know the properties of the stars being orbited. For a planet's size, precisely characterizing the host star can mean the difference in our understanding of whether a distant world is small like Earth or huge like Jupiter.

For astronomers to determine the size of an exoplanet—planets outside the solar system—depends critically on knowing not only the radius of its host star but also whether that star is single or has a close companion. Consider that about half of the stars in the sky are not one but two stars orbiting around each other, this makes knowing the binary property of a star paramount.

If an exoplanet orbits a star in a binary system but astronomers believe the starlight captured by the telescope is from a single star, the real radius of the planet will be larger than measured. The difference in the measured size of the exoplanet can be small ranging from 10 percent to more than a factor of two in size, depending on the brightness of the companion star in the system. ##

## 'Alien Megastructure' Star Targeted by \$100 Million SETI Search

[www.space.com/34505-alien-megastructure-star-seti-search.html](http://www.space.com/34505-alien-megastructure-star-seti-search.html)

( [www.space.com/34303-alien-megastructure-star-strange-dimming-mystery.html](http://www.space.com/34303-alien-megastructure-star-strange-dimming-mystery.html) )

October 26, 2016 – If intelligent aliens actually do live around **Tabby's Star**, astronomers are determined to find them. The Breakthrough Listen initiative, which will spend \$100 million over the next 10 years to hunt for signals possibly produced by alien civilizations, is set to begin studying Tabby's Star with the 330-foot-wide (100 meters) Green Bank Telescope in West Virginia, project team members announced Tuesday (Oct. 25).

The Green Bank Telescope is the largest fully steerable radio telescope on Earth, and it's the largest, most sensitive telescope that's capable of looking at Tabby's star given its position in the sky."

KIC 8462852 hit the headlines last September, when a team of astronomers announced that the star had dimmed dramatically several times over the past few years — in one case, by a whopping 22%. These brightness dips are too significant to be caused by an orbiting planet, so scientists began suggesting alternative explanations. ##

## Breakthrough Listen to search for intelligent life around weird star

<http://phys.org/news/2016-10-astronomers-gravitationally-lensed-galaxy-properties.html>

October 26, 2016 – Although the universe started out with a bang it quickly evolved to a relatively cool, dark place. After a few hundred thousand years the lights came back on and scientists are still trying to figure out why. Astronomers know that reionization made the universe transparent by allowing light from distant galaxies to travel almost freely through the cosmos to reach us.

However, astronomers don't fully understand the escape rate of ionizing photons from early galaxies. That escape rate is a crucial, but still a poorly constrained value: there are a wide range of upper and lower limits in the models developed by astronomers.

That limitation is in part due to the fact that astronomers have been limited to indirect methods of observation of ionizing photons, meaning they may only see a few pixels of the object and then make assumptions about unseen aspects. Direct detection, or directly observing an object such as a galaxy with a telescope, would provide a much better estimate of their escape rate. ##

## BROWN DWARFS

### Scientists detect radio emission from a nearby brown dwarf

July 6, 2016 – <http://phys.org/news/2016-07-scientists-radio-emission-nearby-brown.html>

Located some 23 light years away, the brown dwarf designated WISEP J060738.65+242953.4 or W0607+24 for short, turns out to be a source of radio emission. According to a research paper published July 4, this substellar object showcases quiescent radio emission, making it one of the most radio-faint, ultra-cool dwarfs yet detected.

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

Brown dwarfs like W0607+24 are objects that are too large to be called planets and too small to be stars. **With a mass below that necessary to maintain hydrogen-burning nuclear fusion reactions**, they are **much cooler and dimmer than main sequence stars**. These objects could be also sources of radio emission, but the cause of this process is still not completely understood.

Editor: **Brown Dwarfs could easily have "planets" or "moons" like Jupiter's Europa. And that is why we personally are fascinated by Europa and what lies in its global ocean below its thick ice crust. "Europids" are likely to far outnumber surface-life bearing planets like out Earth. PK ##**

## Brown dwarfs reveal exoplanets' secrets

August 15, 2016 - <http://phys.org/news/2016-08-brown-dwarfs-reveal-exoplanets-secrets.html>

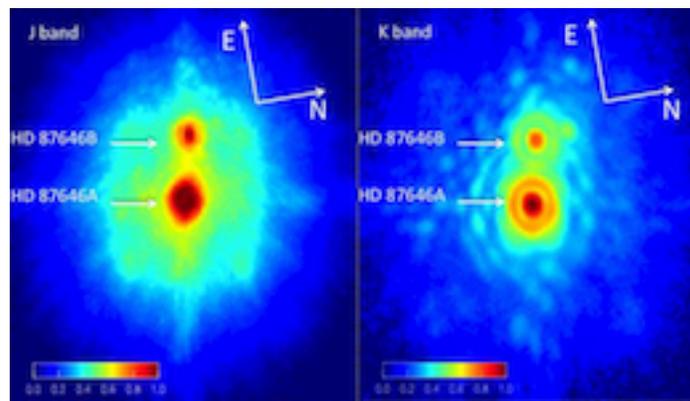
Brown dwarfs are smaller than stars, (too small to sustain nuclear fusion) but more massive than giant planets. As such, they provide a natural link between astronomy and planetary science. However, they also show incredible variation when it comes to size, temperature, chemistry, and more, which makes them difficult to understand, too. they also show incredible variation when it comes to size, temperature, chemistry, and more, which makes them difficult to understand, too.

New work led by Carnegie's Jacqueline Faherty surveyed various properties of 152 suspected young [brown dwarfs](#) in order to categorize their diversity and found that atmospheric properties may be behind much of their differences, a discovery that may apply to planets outside the solar system as well.

## Giant planet & brown dwarf discovered in a close binary system HD 87646

August 16, 2016 - <http://phys.org/news/2016-08-giant-planet-brown-dwarf-binary.html>

An international team of astronomers reports the discovery of a giant planet and a brown dwarf in a close binary system designated HD 87646. The findings, described in a paper published Aug. 11 on arXiv.org, reveal that HD 87646 is the first close binary system with more than one substellar circum-primary companion known to date.



HD 87646, located around 240 light years away, is a bright G-type star with a fainter K-type stellar companion. The primary star in the system, HD 87646A, is about 12 % more massive than the Sun and has a radius of about 1.55 solar radii. The system has a separation of only 22 AU between the two. #

## OUR GALAXY - THE "MILKY WAY"

### Astronomers discover dizzying spin of the Milky Way galaxy's 'halo'

July 25, 2016 - <http://phys.org/news/2016-07-astronomers-dizzying-milky-galaxy-halo.html>

Astronomers at the University of Michigan's College of Literature, Science, and the Arts (LSA) discovered for the first time that the hot gas in the halo of the Milky Way galaxy is spinning in the same direction and at comparable speed as the galaxy's disk, which contains our stars, planets, gas, and dust. This new knowledge sheds light on how individual atoms have assembled into stars, planets, and galaxies like our own, and what the future holds for these galaxies.

### Astrophysicists discover mechanism for spiral-arm formation in disk galaxies

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

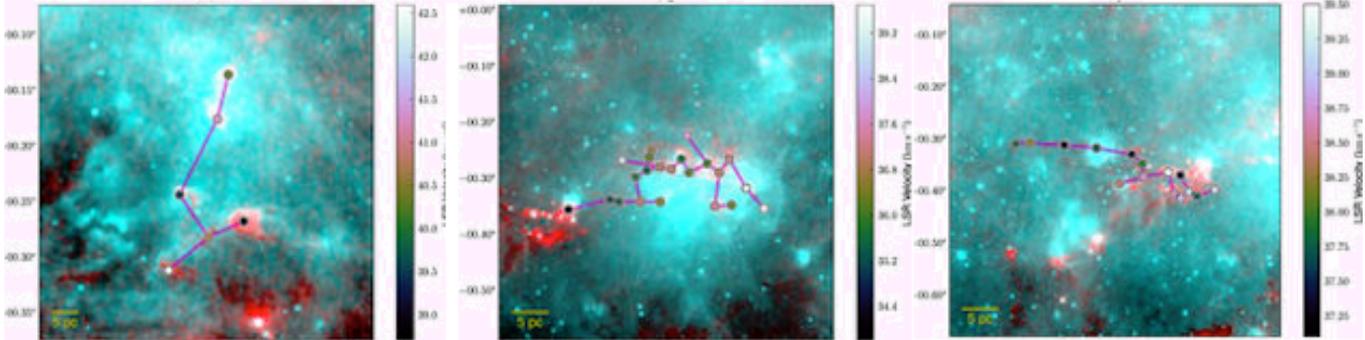
<http://phys.org/news/2016-08-astrophysicists-mechanism-spiral-arm-formation-disk.html>

August 11, 2016 - Astrophysicists at the University of Arkansas have discovered a mechanism for the formation of the spiral arms in disk galaxies. Spiral arms are the elongated and curved spiral sections that are connected to the center of a spiral galaxy, such as our own Milky Way.

The discovery provides a better understanding for the formation of spiral arms in a kind of disk galaxy known as a spiral galaxy. ##

## Milky Way “Bone” Hunters Turn Up Huge New Bounty

[www.space.com/34188-milky-way-bone-hunters-find-galactic-bounty.html](http://www.space.com/34188-milky-way-bone-hunters-find-galactic-bounty.html)



One of three rows of images whose features indicate interesting key features of the Milky Way  
September 12, 2016 - A new study has identified 54 cold, dense gas filaments found the Milky Way galaxy. These features are also sometimes called galactic "bones" long, cold, dense filaments of gas that have been discovered running through the center of the Milky Way's spiral arms. But many other filaments have also been found in the fringes of the galactic arms, or in between them, prompting questions about where these features form.

The team used a computer algorithm to identify the filaments (previous investigations have searched for these filaments "by eye."). The authors say the method can help them begin to answer questions about how the filaments formed, how they affect the growth and development of the galaxy, and what happens to them over time. ##

## Mapping our galaxy: The Milky Way revealed

<http://phys.org/news/2016-09-galaxy-milky-revealed.html>

September 13, 2016 - The European Space Agency will unveil on Sept. 14, a three-dimensional map of a billion stars in our galaxy 1,000 times more complete than anything existing today. A space-based probe called Gaia, launched in December 2013, has been circling the Sun 1.5 million kilometres (nearly a million miles) beyond Earth's orbit and has been discreetly snapping pictures of the Milky Way.

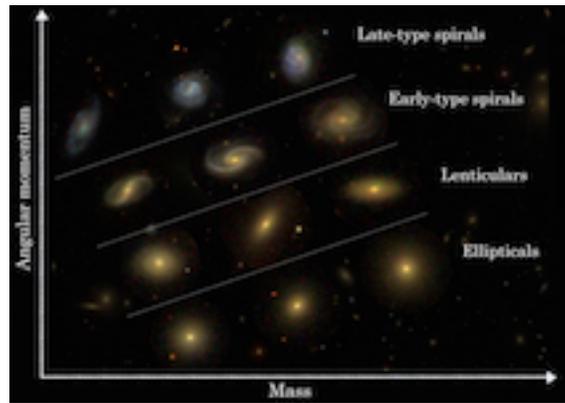
The satellite's billion-pixel camera, the largest ever in space, is so powerful it would be able to gauge the diameter of a human hair at a distance of 1,000 k (620 mi), meaning nearby stars have been located with unprecedented accuracy.

Just over half-way through its five-year mission, Gaia's two telescopes have located a billion stars. That's still only 1% of the Milky Way's estimated stellar population, scattered over an area 100,000 light years in diameter. ##

### OTHER GALAXIES

## Astronomers shed light on different galaxy types

<http://phys.org/news/2016-09-astronomers-galaxy.html>



Full-size image: <http://cdn.phys.org/newman/gfx/news/hires/2016/10-astronomers.jpg>  
 September 14, 2016 – Australian scientists have taken a critical step towards understanding why different types of galaxies exist throughout the Universe. The research, made possible by cutting-edge AAO instrumentation, means that astronomers can now classify galaxies according to their physical properties rather than human interpretation of a galaxy's appearance.

## THE UNIVERSE AT LARGE

### How Can the Universe Expand Faster Than the Speed of Light?

<http://www.space.com/33306-how-does-the-universe-expand-faster-than-light.html>

As dark energy causes the universe to expand ever-faster, it may spur some very distant galaxies to apparently move faster than the speed of light. This Hubble Deep Field Image shows some of the most distant galaxies ever observed.

#### How can the universe expand faster than light travels?

It seems like it should be illegal, doesn't it? Over and over we're told the supreme iron law of the universe: Nothing — absolutely nothing — can go faster than the speed of light. Done. Nothing further needs to be said about the issue. And then come the astronomers, always excited by the chance to mess up your comfort zone. They come barging in with a simple observation: Some galaxies are moving away from us...wait for it...faster than the speed of light. **What gives?** ##

### Cosmic Clocks Keep Time in the Search for Gravitational Waves

August 1, 2016 – [www.space.com/33540-cosmic-clocks-search-for-gravitational-waves.html](http://www.space.com/33540-cosmic-clocks-search-for-gravitational-waves.html)

With cosmic clocks, an interruption could mean the passing of a ripple in the fabric of space and time. The clocks in this case are pulsars — objects in the sky that appear to blink rapidly, such as strobe lights. A group of scientists spread out around the world are keeping a careful watch on a handful of pulsars to try to detect those ripples in the fabric of reality, also known as gravitational waves. These pulsar experiments require an incredible amount of patience; some of them have been collecting data for over a decade, and optimistic predictions say it could be another three to five years before they find what they're looking for. ##

### NASA's Fermi mission expands its search for dark matter

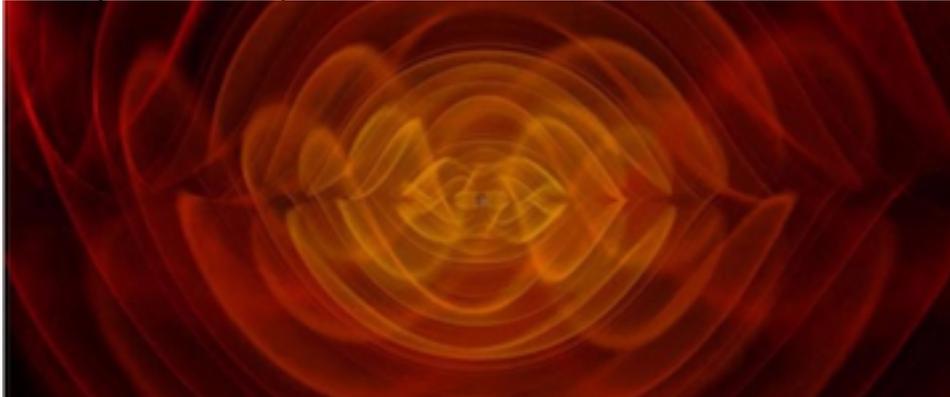
August 12, 2016 – <http://phys.org/news/2016-08-nasa-fermi-mission-dark.html>

Dark matter, the mysterious substance that constitutes most of the material universe, remains as elusive as ever. Although experiments on the ground and in space have yet to find a trace of dark matter, the results are helping scientists rule out some of the many theoretical possibilities. Three studies published earlier this year, using six or more years of data from NASA's Fermi Gamma-ray Space Telescope, have broadened the mission's dark matter hunt using some novel approaches.

### US Should Reenter Space-Based Hunt for Space-Time Ripples

[www.space.com/33744-american-astronomy-hunt-for-space-time-ripples-report.html](http://www.space.com/33744-american-astronomy-hunt-for-space-time-ripples-report.html)

August 15, 2016 – The United States could reenter a space-based hunt for ripples in space-time, according to the National Academy of Sciences, Engineering and Medicine, responsible for producing a decadal report that provides funding agencies and the entire astrophysics community with a proposed roadmap for the coming years. The report gives suggestions for which projects and avenues of research the community should prioritize and pursue.



This is a visualization of gravitational waves, ripples in space-time predicted by Albert Einstein.

## The Universe Is Directionless, Study Finds

[www.space.com/34189-universe-is-directionless-study-finds.html](http://www.space.com/34189-universe-is-directionless-study-finds.html)

September 26, 2016 – The universe, it turns out, looks the same in every direction. Of course, this isn't true on a "small scale" — the stars, galaxies, dark matter and interstellar gas that fill the universe are strewn about and clumped together in unique ways. But on a much size scale encompassing the entire universe, new research shows the cosmic landscape doesn't have any preferred direction — there's no axis of spin like the Earth, no massive asymmetries that would orient a cosmic traveler.

The new study appears to be the most in-depth attempt to answer this question, which confirms a long-held assumption in physics. In addition, it touches on the idea that Earth does not occupy a special place in the universe by showing that not only is no preferred location in the universe, there is no preferred direction.

If the large-scale structure of the universe is anisotropic — different depending on the direction it is viewed from — that feature would have been present from the get-go. ##

## Europe Exploring Solar System & Beyond With Spacecraft Fleet | Video

[www.space.com/34032-europe-exploring-solar-system-and-beyond-with-spacecraft-fleet-video.html](http://www.space.com/34032-europe-exploring-solar-system-and-beyond-with-spacecraft-fleet-video.html)

Several European Space Agency (ESA) missions currently underway and in the future have and will give humanity a better understanding of our Universe. Missions include: Planck, Euclid, Gaia, Herschel, Mars Express and more.

**Editor:** This is a "MUST WATCH VIDEO" that will go a long way to informing the reader where we are now in our understanding of the Universe, and its history. ##

### ONLINE OP-ED ARTICLES FROM OTHER WRITERS WORTH READING

#### A stepping-stone to commercial space stations

<http://www.thespacereview.com/article/3033/1> by Jeff Foust

#### Re-evaluating the Moon's role in Earth's past and future

<http://www.thespacereview.com/article/3031/1> by Peter Kokh

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

## Making it in space

<http://www.thespacereview.com/article/3036/1> by Jeff Foust

## Is the Moon a necessary step on the path to Mars?

<http://www.thespacereview.com/article/3040/1> by Chris Carberry and Rick Zucker

## CubeSats: faster and cheaper, but better?

<http://www.thespacereview.com/article/3047/1> <http://www.thespacereview.com/article/3050/1>

## Review: "All These Worlds Are Yours"

<http://www.thespacereview.com/article/3059/1> by Jeff Foust

[The book offers a concise overview of astrobiology and what we know—and, more importantly, what we don't—about the search for life elsewhere in our solar system and beyond.]

## Review: Economic Development of Low Earth Orbit

<http://www.thespacereview.com/article/3050/1> by Jeff Foust

"NASA is making a major bet on the future of commercial space activities in low Earth orbit. The agency has been increasingly emphasizing commercial use of the International Space Station, ranging from experiments performed there to the use of the station as a launch pad for smallsats and, just recently, soliciting ideas for installing a commercial module on the ISS (see "[A stepping-stone to commercial space stations](#)", The Space Review, July 25, 2016). The goal of this is to stimulate both a demand for various commercial activities in LEO, and a supply of facilities to service that demand, that can continue after the ISS is retired some time in the mid to late 2020s."

## Different paths to Mars

<http://www.thespacereview.com/article/3070/1> by Jeff Foust

## Unpopular truths about space settlement

<http://www.thespacereview.com/article/3068/1> by Alan Wasser

## Settling Mars is a lot more than Rocket Science

By Jeffrey Liss (via email to the editor)

### Concerning Elon Musks recent presentations

[www.space.com/34186-nasa-odds-favor-successful-spacex-mars-mission.html](http://www.space.com/34186-nasa-odds-favor-successful-spacex-mars-mission.html)

[www.space.com/34192-spacex-raptor-rocket-test-first-photos.html](http://www.space.com/34192-spacex-raptor-rocket-test-first-photos.html)

[www.space.com/34211-spacex-mars-interplanetary-transport-concept-video.html](http://www.space.com/34211-spacex-mars-interplanetary-transport-concept-video.html)

[www.space.com/34209-spacex-mars-spaceship-animation.html](http://www.space.com/34209-spacex-mars-spaceship-animation.html)

Elon Musk is to be congratulated, again, both for his vision and for his willingness to put his money where his heart is. I didn't hear his presentation but saw his slides that Dale Skran kindly provided. Elon's plans for Mars have four great pluses:

- (1) A coherent plan for getting there;
- (2) a source other than a Government program;
- (3) a relatively fast timetable; and, especially,
- (4) a big boost for a public focus on and interest in the goal of space settlement.

Not being a rocket scientist, I will assume for the time being that the rocketry will work.

However, there was a certain appropriateness in having the Fall issue of **Ad Astra** arrive in our mailboxes a day or so before Elon's public unveiling of his plan. The Ad Astra article by John F. Kross, "**Careful: Baby on Board! Rocketing the Cradle to Mars,**" is a dash of cold water realism to temper our hot flare of enthusiasm. My compliments to the Editors of Ad Astra.

Elon told us how to get there -- but he did not (at least this month) tell us how -- OR IF -- the colonists can survive once they get there.

Kross lists a **few of the challenges**: relentless rain of radiation, planet-wide powdery poison, weighty implications of reduced gravity, avoiding oxygen toxicity, the perils of being "stressed out." Apart from the chilling concern of long-term and unavoidable effects of 3/8 G, just thinking of what kinds of abodes colonists might build immediately upon landing is by itself pretty daunting.

**Bottom line:** Settling Mars is a lot more than rocket science.

While Elon is putting his money into getting there, he and many others will need to put in a lot of thought and research about what happens then. ##

**Editor:** That said, I have addressed many of these questions in some of my many articles on Mars in past issues of *Moon Miners' Manifesto*.- [www.moonsociety.org/publications/mmm\\_themes/mmmt\\_Mars.pdf](http://www.moonsociety.org/publications/mmm_themes/mmmt_Mars.pdf)

## The next issue, TTSIQ #18, due the end of January 2017, will be the last.

I have very much enjoyed putting together *To The Stars International Quarterly*, and its predecessor, *Moon Miners' Manifesto India Quarterly* for the past several years. As to *Moon Miners' Manifesto* itself, the coming December issue, #301, the 30<sup>th</sup> anniversary issue, will be the last. I am retiring to work on two books, proposed tittles: "A Pioneer's Guide to the Moon", and "The Future Factor: what makes the universe tick, and everything in it."



But, I will also be introducing a new publication: "**Outbound: the Moon, Mars, and Beyond.**" no schedule, no set format, no set length, and available in **pdf** file format only. In addition to new articles and news comments, "OMMB" may also include a list of links to select news items: a short form of TTS. **How to get OMMB?** To be determined. Stay tuned.

## To The Stars International Quarterly Editorial Team

TTSIQ is a project of the National Space Society's International Committee



L>R: Peter Kokh – [kokhmmm@aol.com](mailto:kokhmmm@aol.com) – [http://www.lunarpedia.org/index.php?title=Peter\\_Kokh](http://www.lunarpedia.org/index.php?title=Peter_Kokh)  
President Milwaukee Lunar Reclamation Society – Editor of *Moon Miners' Manifesto* – Life member National Space Society – Past president the Moon Society 2004–2011, Milwaukee, Wisconsin US

**Madhu Thangavelu** – [thangavelu-girardey@cox.net](mailto:thangavelu-girardey@cox.net) – Mother from Kerala, India. Father from Tamil Nadu, India – grew up in Delhi – now teaching at the University of Southern California – Conductor,

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Graduate Space Exploration Concept Studio USC School of Engineering & Architecture – co-author of “The Moon: Resources, Future Development, and Settlement”.– Los Angeles, California US\

**David A. Dunlop** – [dunlop712@yahoo.com](mailto:dunlop712@yahoo.com) – Moon Society Director of Project Development – Executive Director of LUNAX (LUNar National Agriculture eXperimnet) – University of Luna Project – Chair NSS International Committee – Green Bay, Wisconsin US

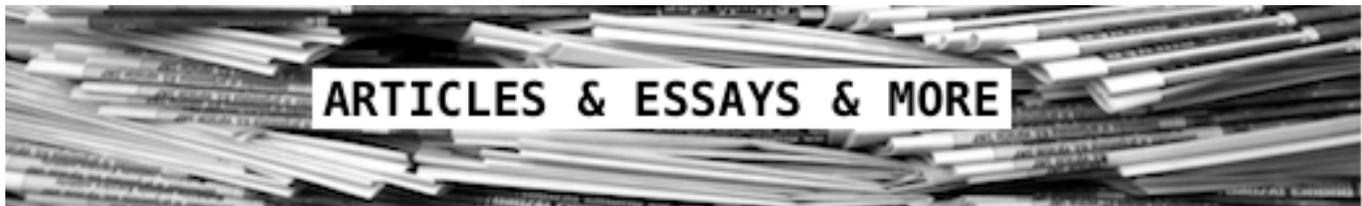
**Al Anzaldua** – [alanzaldua706@yahoo.com](mailto:alanzaldua706@yahoo.com) – – President Tucson L5 Space Society, Tucson, Arizona,



**L: Srinivas Laxman** – [moonshotindia@gmail.com](mailto:moonshotindia@gmail.com) – Mumbai – author “MoonShot India”

**M: Lynn Zielinski**, NSS Educational Committee – [lzielinski@comcast.net](mailto:lzielinski@comcast.net) – Chicago, Illinois, US

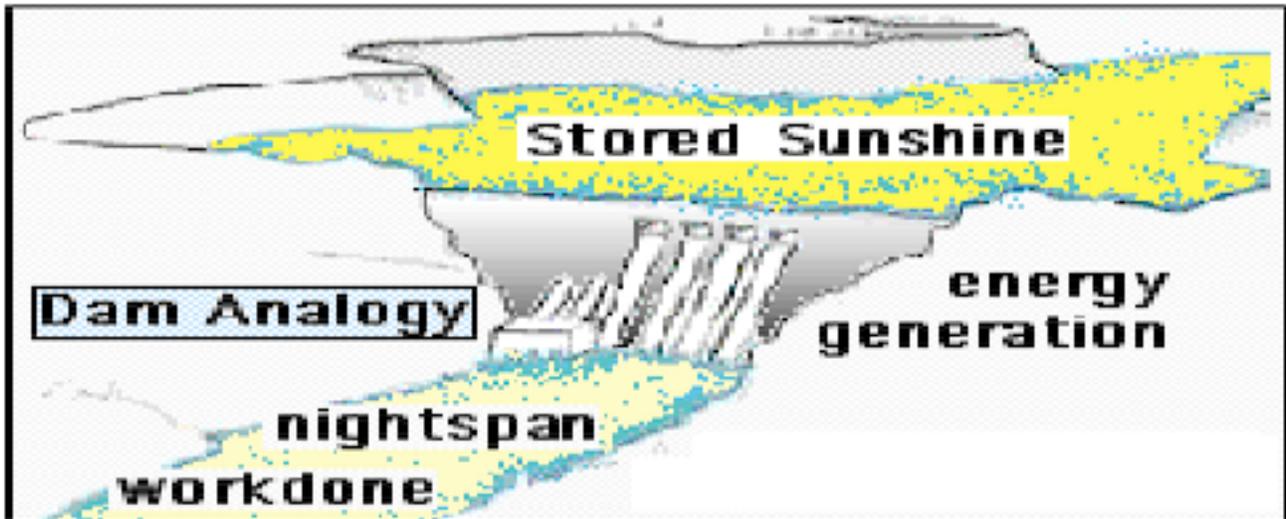
**R: Student Contributor: Aleksandra Voinea** – [aleksa.voinea@gmail.com](mailto:aleksa.voinea@gmail.com) – Bucharest, Romania / Yale U. Ithaca, NY



## “Potentiation”

### A Strategy for Getting through the “Nightspan” on the Moon’s Own Terms

By Peter Kokh



#### Taking Back the Nightspan on the Moon

On Earth, in many urban areas, there is one special night given over to the assertion of everyone’s right to be out and about, safely, at night. “Take back the Night” is aimed at programs that neutralize or reduce nighttime crime and violence that in some areas has frightened people into remaining imprisoned in their homes between sundown and sunup the morning after.

On the Moon, the nightspan is 14.75 days long, 30 times as long as an average terrestrial night. Sunshine is the principal readily tappable local source of energy on the Moon. Its unavailability during the nightspan makes the Moon a forbidding place to many people. If you are one of these, you may need to take a serious look at your pioneer spirit quotient [PSQ]. **In every one of the frontiers of the past, pioneers found themselves challenged by the unavailability of various things they had taken for granted in their native homelands.**

Those who survived, did so by turning to their inner resourcefulness; they “found” ways, not just to make do, but to thrive nonetheless. This inventiveness, this eagerness to take on challenges, seems disturbingly lacking in many space-interested people today, the very segment of the population one would expect to be most **ready to imagineer their way around every obstacle**. Some of these “discouragees” would rely on nuclear power alone.

Nuclear is fine – but it can’t be relied upon 100% and prudent settlers will have backup power generation capacity. To the extent it will serve genuine settlement, not just a token “Kilroy was here” outpost, nuclear has to be “Lunar Nuclear” [based on Thorium-233]. But more on that later.

Other discouragees just give up and would restrict themselves to a couple of tiny sites at both lunar poles where it is “purported” that “sunlight”, always more or less tangential to the surface, is available month around. In fact, the “Peak of Eternal Light” at the south lunar pole enjoys sunlight only 86% of the time with several dark periods. All such spots are inevitably mountain peaks or crater rims, not exactly prime turf upon which to land or erect a base for routine operations.

Some are so intimidated by the lunar nightspan, that they would bypass the Moon altogether in Human expansion into the Solar System.

What we have to say is meant instead for those of you who welcome the challenge of the nightspan. Fully 99.99% of the Moon's surface outside the permashade areas in polar craters experiences alternating two week long dayspans and equally long nightspans. If we are going to "do the Moon", this is the Moon we need to do.

**We will not earn the right to say we have a permanent human presence on the Moon until we have learned how to deal with the Moon on its own terms.**

We have to take back the night, the lunar nightspan from the dread bogeyman of the energy desert that tests us. Lunan pioneers with the right stuff will learn not to fear the night, but to love it and cherish it as an equal movement in life's rhythms.

**Potential Energy Reservoirs**

Potential energy is the reserve energy an object has by virtue of its position in an energy gradient. There are several kinds of "energy hills". All kinds of potential energy reservoirs available on Earth are also available on the Moon. It is up to us to build these various reservoirs, and fill them.

This deliberate effort we dub "potentiation". Potentiation will not only make energy available for the nightspan, it will take energy to put in place. And the unlimited solar energy available everywhere on the Moon outside permanently shaded polar craters is tappable to do the job. The dayspan holds all the keys to the nightspan. But we have to do the right things during dayspan to make our plan work. We have to not only use available solar energy, we must produce a surplus, and store it "uphill". The endless broad and deep river of sunshine can be dammed up. The dams can take various forms of "uphill" holding reservoirs: gravitational, thermal, chemical, angular momentum, and radioactive.

**Gravity Slopes & Hydroelectric Power**

Gravity hills, slopes, gradients, wells: something is placed at the top of a slope, poised to create energy by being allowed to fall. On Earth, we dam up rivers at convenient constricting points. This creates a "head". Water is allowed to spill over the dam in a controlled fashion, gathering momentum from its plunge, and using this momentum to spin turbines that run electric power generators.

No rivers on the Moon? No problem! Wherever we place our outposts and settlements, we will need appreciable amounts of water: as an essential component of whatever minibiospheres we establish to reencradle ourselves; for food production; for drinking, washing, and hygiene; for use as recyclable reagents and handling media in industry. We will need a substantial water surplus, in part consisting of water being recycled and purified.

**During dayspan, solar energy can be used to pump the water surplus uphill: nearby crater rims, rille shoulders, or the surface above lavatubes. At night this water is returned to the loop through tubes plunging to turbine generators downslope.**

Of course, the amount of water available for this form of nightspan energy generation depends on the generosity of the settlement's water endowment. Now that Lunar Prospector has confirmed the discovery of substantial water ice reserves at both lunar poles, this idea is not far-fetched.

What about the low lunar gravity? Won't that work against the idea? Well, Niagara Falls, which produces a lot of power, has a head of about 150 feet/47 meters..

To match that head, we'd need a reservoir 6 times as high above the generator turbines, or 900 feet up. Some Crater rims are 10,000 feet/3.048 meters (or more above the crater floors.

Many mare coastal sites are near high rampart mountains. These sites are advantaged by access to both major suites of regolith materials (highland soils rich in aluminum, calcium, and magnesium, and mare soils enriched in iron and titanium). Even mid-mare sites that involve the use of lavatubes will come with ready "heads" of several hundred meters between the exposed surface and the floor of the tube underneath. Nor is a Niagara-equivalent head needed. There are many working low-head hydroelectric sites around the country in the 20 ft. range. Where there are no natural "heads" for reservoir placement, we can simply build water towers hundreds of feet high, using dayspan solar to pump them full.

Now let's play with this idea. Dayspan sunshine can also be used to purify and treat the water in the reservoir - if the reservoir is covered with ultraviolet transparent quartz (pure silicon dioxide glass). Going a step further, dayspan sunshine can be used to electrolyze this stored treated water into oxygen and hydrogen. After nightfall, the hydrogen and oxygen can be recombined in a bank of fuel cells, producing both energy on the spot, plus the water to fall downhill to the generator turbines, producing yet more energy. All these processes would have to be paced to extend this potential energy resource

through the long nightspan. Lunar Hydroelectric as sketched above, is the brainchild of Myles A. Mullikin, Lunar Reclamation Society cofounder. It was one of several of his major contributions to our "Prinzton" runner up entry in NSS's Space Habitat Design Competition during the winter of '88-'89. Hydroelectric power on the Moon is the last thing that occurs to most people mulling the problem. But it turns out to be very realistic for any kind of outpost or settlement. No one pretends the amount of energy stored during dayspan and produced during nightspan by a hydroelectric scheme will meet all the settlement's power needs. But it is one workable component of a mix pioneers will have up their sleeves. Planners should consider incorporating such interactive water storage into the settlement utility system.

{The rest of this very long article is not printed above because it is not germane to the topic. PK}

Topic continued below

# Hydr Luna

Myles Mullikin and Peter Kokh (1989) (condensed by editor)

## Foreward

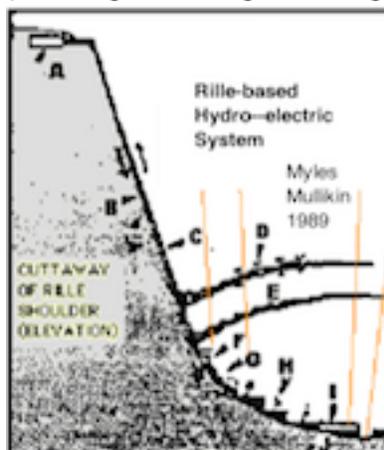
In 1989, the Milwaukee Lunar Reclamation Society chapter of the National Space Society decided to enter an National Space Society contest to design a lunar settlement of a set size, 1-5 thousand pioneers. Our three village settlement built within a rille and dubbed tongue-in-cheek "Prinzton" for its site near the crater Prinz (SE of Aristarchus) came in second. (The winning proposal did not satisfy all the design criteria, but was that of a single architectural student and therefore a more fitting recipient of the \$2,000 prize.) Eight people from the chapter worked on Prinzton.

## Copernicus Construction Company

Copernicus Construction Company is no more than the whimsical name we in the Lunar Reclamation Society picked to refer to our "Define & Design" fun-activity brainstorming group. In the fall and winter of 1988-89, against expected fierce heavyweight competition from groups like Seattle L5's Boeing-laden SLuGS [Seattle Lunar Group Studies], we had decided to enter the National Space Society's Space Habitat Design Competition: Category - Lunar Base for 1,000-5,000 people. Our three village settlement built within a rille and dubbed "Prinzton" for its site near the crater Prinz (SE of Aristarchus)

[http://www.moonsociety.org/publications/mmm\\_papers/rille\\_paper1.htm](http://www.moonsociety.org/publications/mmm_papers/rille_paper1.htm)

Surely, one of the most innovative ideas proposed for the Prinzton Project was Myles A. Mullikin's suggestion that we use the elevation differences within the rille to circulate water through a modest hydroelectric plant. During the two day-weeks when abundant solar power wae available, water reserves would be pumped by solar power from a valley bottom reservoir to one on top of the rille shoulder. It would be no problem to pump the water up that high, and the greater head, some 400 meters, even in 1/6th gravity, would still be effectively **half again as high as Niagara Falls!**



Out on the rille-top, the water pumped up from below could circulate under quartz panels transparent to the Sun's ultraviolet fury. This would serve as both germicide and bactericide. And if still desired, water in the upper reservoir could be electrolyzed to be recombined in fuel cells with the onset

of night before beginning its fall down the conduits to the generating station below. There would be no appreciable safety risks involved.

A second set of tubes up the rille slope would carry air rushing counterflow as it is displaced by the water being pumped up or falling down as the case may be. Air pressure in the rille-top reservoir would have to be the same as in the village below. A heat-exchange system could cool hot upper reservoir air before it flowed into the village during the day time, giving up heat to the water. The whole system would act as a thermal flywheel to give the rille bottom settlement a most equable climate.

Meanwhile, the generating station could be placed with little sacrifice in power at the top of the Town terraces, the spent water then free to work its way down a series of ponds and cascades to a central lagoon for all to enjoy. A shallow lagoon with canoes, fishermen, and pink flamingos would be cantilevered over the final reservoir with depth maintaining overflow tubes leading from one to the other.

Some of the water from the Hydro station could also be shunted to pressure-fed fountains, further adding to the character of this village. While the extra power to be gained by the hydroelectric scheme as opposed to the straightforward fuel cell system, is probably very modest given the limited volume of water probably available, it might well be proportionate to the extra lighting and energy load the twenty-four hour character that the settlements Metro District would have.

#### **Other locations suitable for lunar hydro-electric systems**

Rilles are neither rare nor common. We may want to establish settlements in locations where there aren't any. What are the options suitable for this type of dayspan-nightspace power system?

Such hydroelectric systems could be built where we find **lavatube "skylights"** – places where the roof of a near-surface lavatube has collapsed to admit by a large enough meteorite.

**But a nearby crater of sufficient vertical elevation differences between crater rim and crater bottom will do.** While the Moon's gravity is only 1/6<sup>th</sup> that of Earth's, there will be handy craters near most settlement sites with more than ample rim to bottom elevation difference.

#### **The upshot:**

### **THERE IS NO NEED TO START LUNAR SETTLEMENT AT THE POLES**

#### **Sunshine is not the only source of available energy:**

Water ice is available in craters of sufficient size and depth as far as 30° from the poles according to Lunar Prospector findings. That would allow choosing a starter settlement site along the north "shore" of Mare Frigoris-Sinus Roris, 1,500 miles (2,400 km) across East to West, where highland regolith and mare regolith meet, allowing a much much wider choice of raw materials for all sorts of industrial uses.

Settlements all along the route could be connected by a 150° long power line so that all locations had access to solar power 85 % of the dayspan-nightspace cycle, almost as good as polar locations.

But that is another topic. PK

## **"Reimagining" the Moon as a World to be Settled, not just Explored**

[Below is a collection of relevant articles through the years]

By Peter Kokh [FROM Moon Miners Manifesto #43 – MARCH 1991]

### **The Moon's monthly cycle through its phases will affect how Lunans live, work, and play.**

#### **"DAYSPAN"**

For the watchers on the ridge, it begins with an arcing flame of light punctuating the still dark eastern horizon -- part of the solar corona, something that the atmosphere-coddled Earthbound can never see, except during locally exceedingly rare 'total' solar eclipses. The Sun's intense disk is now still below the horizon, but this great prominence announces its imminent arrival onto the moonscape.

Here on the Moon, the Sun rises with great deliberation. From 'first contact' when the first diamond glint of light from the solar surface itself breaches the horizon, until 'last contact' when the entire blazing disk has just cleared, the Sun takes sixty ceremonial minutes to make its entrance. For such is the slowness with which the Moon turns on its axis to bring the Sun into view. (On the fast turning Earth, this show is run through in fast-forward so that it amounts to no more than a two-minute

skit.) Two hours later, the Sun will have cleared the horizon by only a degree. It will not reach the far horizon, 180 degrees away, for another 14 3/4 days, better than two weeks.

But already this first standard day of the new sunrise, there is a noticeable shift in settlement activity and a quickening of its pace. Within a few hours of first light, solar panels and/or solar dishes, and the many sun-tracking, grabbing, and channeling heliostats will have all locked on to its life- and energy-giving rays.

The Sun is both workhorse and taskmaster for the little community. With its return, added electrical power surges online. Solar furnaces melt charges of raw, or refined, regolith for the productions of sundry items from cast basalt, ceramics, glass, and glass-glass composites or Glax™. The concentrated rays are also put to work sintering iron fines scattered abundantly in the loose regolith blanket, and collected with a simple magnet, into assorted useful pieces using powdered metal technology. And either directly through focused heat, or indirectly through electricity, industrial-strength sunshine begins cracking water reserves back into hydrogen and oxygen for use in fuel cells aboard field vehicles and, stockpiled until sunset, for reserve night-span power generation.

“Make hay while the Sun shines!” Not only does the pace of mining, processing, manufacturing, and field activities such as construction, road building, and prospecting, rise dramatically, but so does that of farming and home sunspace gardening. Plants emerge from their ‘subsistence diet’ of reduced artificial lighting during the nightspan, thrive anew and resume their progress towards eventual harvest. For most of the base personnel or settler population, the tempo of life has significantly accelerated.

More people venture abroad, “out-vac”, either for work or just for a welcome change of scenery, excursion vehicles being popular choices over cumbersome spacesuits. “Selenologists,” still lazily called ‘geologists’ by their Earth-tied colleagues, venture out of their labs to collect fresh samples in the field.

Habitats and pressurized common spaces (the “middoors”) are flooded with soulwarming sunshine, thanks to the heliostats, which filter out both the unwanted heat of the infrared and the harmful fury of the ultraviolet rays. Stained glass and prisms turn sunbeams into a painter’s palette and interior and middoor surfaces take on a new glory. Walls, finished with a cheap whitewash of CaO lime or TiO titanium oxide suspended in a waterglass medium of hydrous sodium silicate, make an ideal canvas for these rainbow-bright live paintings. Greenery, its verdant hues more vivid after ‘breakfast’, completes this characteristic settlement color scheme.

Oases of park space tucked into crannies of the various food-raising areas are thronged during free time. Schoolyard recess is imbued with renewed spirit. Those going to and from work along pressurized passageways lined with carefully chosen plantings seem to smile with a

Any ship carrying tourists will arrive while the Sun illuminates the area. Perhaps most of the visitors will stay to experience the full rhythm of settlement life, and depart during the following dayspan some three or four weeks later.

Long forgotten is the ho-hum grudging routine of daybreak on Earth, oft’ equated with life before coffee. Here the Sun’s glorious presence transforms everything through and through. For the fourteen plus 24-hour days of dayspan, the life of most settlers will be one of especially earnest industriousness. In every field of dayspan-reserved activities, there will be important production goals to meet if these brash settlers are to “set themselves up” for the quite different, but complementary, routine to follow.

## “NIGHTSPAN”

For the previous two plus weeks, this unlikely pocket of humanity on the Moon has been a beehive of activity, making use of the Sun’s heat, its life-giving rays, and its electrical generating potential, to work through the more energy intensive portion of the long list of tasks needed to keep the community going. For total available on-line power will drop measurably as the Sun finally reaches the western horizon.

While the light available on the surface will remain full-strength until the final two minutes, ‘down below’ the level of redirected sunlight will have begun to taper off the past day or so as heliostats on the surface, even arranged in purposely staggered rows, begin to eclipse one another, cutting off solar access.

Industries dependent on harnessed and concentrated sunlight will have been located to avoid this problem, so they can keep working on full throttle for the full duration of ‘sun-up’. Finally, however, the great solar furnaces and turbines will be shut down and the activities they support will stop. Those

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industries that depend indirectly on abundant electricity generated by solar arrays must likewise phase down. For whether supplied by standby nukes, fuel cells, spinners, or hydroelectric generators (where rille or crater slopes allow the possibility of pumping up water surplus by dayspan to let it fall during the nightspan), the total amount of on-line electrical power will be likely be appreciably reduced for the fortnight to come. Industry after industry will switch gears, taking up now the rather more labor-intensive tasks that it had strategically postponed during dayspan.

Maintenance, repairs, and changeout of equipment; assembly and finishing; packaging for shipment; bookwork and inventory – for many workers, it will be rather like switching jobs every two weeks. And perhaps that will be a welcome break in the routine, an anticipated and appreciated periodic shot in the arm, an essential element in sustaining personal and communal morale.

Workers who by dayspan crew those industries that do not have a proportionate list of postponable energy-light labor-heavy tasks to keep them busy during nightspan, might shift to quite different company co-owned ventures that are task-lopsided the other way. Unneeded farm workers might move to food-processing duties etcetera. Continuing education, especially in the line of one's work, might be preferentially scheduled for nightspan.

The Sun now set, Lunans, temporary personnel and permanent settlers alike, will find more leisure time for arts and crafts and cottage industry pursuits. Music, dance and other performing arts will vie for attention. Now there may be more time for shopping and flea market barter. Perhaps only necessities will be bought and sold during dayspan when able persons are best occupied building up export inventories to defray import costs, and producing domestic items to reduce import demand.

Fresh new pioneer recruits may have arrived shortly before sundown. This will give thema taste of what dayspan settlement life is like, saving more intensive orientation for the nightspan when extra senior personnel will be freed up from other duties to devote themselves to this task.

The public spaces of the settlement – its mid-door squares, streets, alleys and passageways – might be more crowded during nightspan with people free to linger leisurely and enjoy activities for which there was little time the two hustling weeks before. Such places will come alive with entertainers and soap box orators, artists and craftsmen selling their wares or demonstrating their talents and taking in serviceable but prosaic “issue” items for customizing makeover into items of pride, hucksters selling similar items on commission, secondhand stalls and exchanges for recyclable items, shelves of produce harvested from inhome gardens and specialty jars of preserves put up by enterprising home-canners – you get the idea.

Ambience provided by electric lighting can take several forms. Great electric lamps might use those same sunshine-delivery systems slaved to heliostats during dayspan to provide periods of simulated daylight each nightspan ‘day’, with subtle mood-setting lighting for nightspan ‘nights’ (night life and sleep time).

And color? Colored bulbs as well as stained glass diff users and dividers will be one way to provide a magically cheerful touch. A harvest of neon and other noble gases adsorbed from the Solar Wind to the fines of the Moon's regolith soil blanket, and recovered by heating during the routine soil-moving processes of mining, road building, and construction, could lead to ample and creative use of neon lights. The “Greek Isles” look of the community's middoor and indoor spaces, in which sunlight splashes whitewashed walls accented with luxuriant greenery, will be upstaged now by quite a different enchantment after dark. It seems unlikely that our future Lunans will fear the night!

At last, the end of the long nightspan will draw near, and the last evening meal of nightspan may become a special one in settler homes, filled with anticipation, maybe even ceremony: “**Sunrise Eve!**”

## **Quite a different situation on Mars**

On Mars, the day-night cycle is just 39 minutes longer than Earth's 24 hour cycle. “Night People” will love those extra minutes, But morning people, those freaks like this writer who can't wait to get the new day started, will be off schedule every day – a version of “jet lag” that gets worse day after day. Night people will adjust much better. Us morning freaks will do better on the Moon, where the clock is reset a bit every couple of months or “sunths.”

## **Lunans mark the days by the Month or “SUNTH”**

It should be clear from the above pieces that the arrival of sunrise and, a fortnight later, of sunset will radically determine the scheduling of almost every activity within a lunar community beyond eating and sleeping. Given that most Lunan industries and enterprises must stop to shift gears at both sunrise and sunset, it will be of no small benefit to their efficient operation to schedule “weekend” breaks so that they always fall at the same time in relation to these all-transfiguring events. As the Lunar settlement will be “under the gun” to produce enough exports to balance the cost of needed imports, as well as enough domestic goods to minimize that import need, achieving such smooth operation is not a goal to be dismissed.

But here’s the rub. Sunsets repeat every 29.5 days (twice every 59 days) or 12 times a year with 11 plus days left over. The Jews and Moslems have such a calendar of “lunar months” (a tautology, when you think of it). But the Romans, while inappropriately keeping the word, altered the “month” so that an even dozen fit in each solar year. For us on Earth, where the really significant repeaters, affecting business cycles as well as agriculture, are the seasons whose onset is determined by our annual orbit around the Sun, quite irrespective of the lunar phase of the moment, the solar “month” (how that grates!) makes sense.

If the word “month” is no longer ‘honest’ for our calendrical tomes of 28–31 days, neither does it fit the sunrise to sunrise period on the Moon itself. From the viewpoint of one on the Moon, it is the Sun’s aspect which is significant. Hence our suggestion, [MMM #7 JUL 87, p.9 “Calendar”] that the term “sunth” be coined for the purpose. Astronomers use the term lunation, but as this properly refers to the new moon to new moon period (that is, reckoned from local sunrise at 90° East), it is not sufficiently generic, and again inappropriately refers to the Moon, not the Sun (we would accept Lunar Solation).

Back to our question. Will future Lunans mark the days by Earth’s months or by the local sunth? Perhaps they will use both calendars, side by side, or a special calendar with dual dating. To visitors from Earth, as to those serving temporary tours of duty with no intention of staying for the rest of their lives, the Earth date will be the “real” date, as if our arbitrary notation were some cosmic fact. Even “tory” settlers (those who have made the move in body but not in spirit) will feel reassured by a glance at our familiar Gregorian calendar.

Meanwhile, not only will settlement life totally ignore terrestrial conventions out of practical need, but both exports and imports and the arrival and departure of tourists will pay heed to the local Sun angle (the time of sunth) rather than to the date on Earth. Business and accounting cycles for Lunan entrepreneurs will follow the march of sunths, not months. Even those businesses on Earth trading with the Moon will need to refer to the lunar calendar (or at the lunar phases shown on most ‘normal’ calendars) to help determine shipping times.

From the 59 date sunth-pair to a full “lunar” calendar is a big step, however. For adopting a twelve sunth year of 354 days would put Lunans out of synch with Earth. IF they decide that this is not important, they have three basic options. A) they can simply let their ‘years’ (or ‘calendars’) advance over Earth years without any attempt to make an adjustment, as does Islam, giving it 33 years to our 32, or B) they can add an intercalary thirteenth sunth every second or third years, as does Judaism, or C) let the differences accumulate and add 7 extra sunths at the end of every 19th year (conveniently, there are precisely 235 new moons every 228 calendar months). If this last option seems far out, it does present a neat opportunity for a once-a-generation built-in period for institutional and cultural review. Those extra seven sunths could be collectively be called “renaissance” or “renewal”.

IF keeping in sync with the year as reckoned on Earth is to be desired, sunths could be numbered 1 to 235, rather than named, in a cycle repeated every 19 years, while the year began and ended in lock step with the familiar Earthside cadence.

However the solar year/sunth incongruity is handled, using the sunth to mark the timing of events and activities within the lunar settlement will mean abandoning synchronization with the Sunday through Saturday rhythm so ingrained in us that we assume the day of the week must be a primeval cosmic framework valid in the most distant corner of the universe, even predating it, as some fundamentalists would insist. In fact, not only is the length of the day a purely Earth-local matter of no cosmic significance whatsoever, but the pegging of names to days in a certain suite with a once and for all calibration, is, however traditional, 100% arbitrary.

Nonetheless the week, as it has been handed down to us, is the most stubbornly ingrained piece of our “cultural infrastructure” and has survived all attempts to tamper with it. Making the switch to sunthtime, if pursued in earnest, will mean pegging ‘weekends’ to this beat, i.e. an integral 4 weeks per

sunth, i.e. no leftover days, with each sunth starting the same day of the week. But in every 59 day sunth-pair their are 3 days more than an even 8 weeks. An adjustment can only be made by making 3 weeks out of every 8, 8 days long instead of 7. If each of these extra days was placed to make a long weekend, and used for all holiday observances, this would provide 18 holidays a year, quite in line with American practice, but in a non-disruptive format. A “leap hour” every six or seven ‘weeks’ would keep the 59 day rhythm from drifting, as the sunth is some 44 minutes longer than 29 and a half days.

To avoid confusion (Monday on the Moon while it is Wednesday on Earth, at least this week etc.) Lunans will most likely adopt a totally new set of 7(8) names. The previous MMM article alluded to above, has some creative suggestions for the pioneers.

Another major question to be settled is whether all Lunan communities will observe the same weekend schedule, no matter how many 120-wide ‘date-zones’ they lie apart from one another, or whether local week-ends will fall with local sunrise and sunset. There are strong tradeoff s and they must weigh and choose.

Such a culturally radical switch in time-keeping would neither be to the point on Earth, nor stand as much chance as a snowball in a supernova. However, Lunans will be living in a workaday environment quite unlike anything ever experienced by any Earth bound community to date. For many settlers, the need to declare cultural as well as economic independence from Earth may be strong. In some form or another, Lunans will adopt conventions of time reckoning that pay only loose homage to our week and month. The year will survive, however, not because the Moon shares the Earth’s orbital motion around the Sun, but because the two worlds lie in each other’s backyard, assuring a high volume of trade and real time communication\*.

I think it will be culturally refreshing! – MMM

Firstsun (odd # sunths)								Secundsun (even # sunths)							
A	C	E	Ma	Me	S	T	P	A	C	E	Ma	Me	S	T	P
1	2	3	4	5	6	7		1	2	3	4	5	6	7	
8	9	10	11	12	13	14	15	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22		16	17	18	19	20	21	22	
23	24	25	26	27	28	29		23	24	25	26	27	28	29	30

A model two “Sunth” Calendar Page showing dayspan/nightspan dates  
 Note that in a pair of “Sunths” 3 weeks out of 8 have an eighth day,  
 most likely enjoyed as part of a 3-day weekend.

## Learning to live *Downwind* and *Downstream* of Ourselves

### Lessons that Earthlings would do well to apply

By Peter Kokh

If there is one likely fatal flaw of current human civilization, it is that we have not yet learned to live downwind and downstream of ourselves. We continue to exhaust our dirty air downwind and to flush our dirty water downstream.

**The Moon has no atmosphere and no hydrosphere.**

**We have to treat our used water and used air**

**so that we can drink waste water again, and breath used air again**

These lessons will hopefully inspire communities on Earth to follow suite. The challenge is that this will take money, money the rich do not want to spend. Lunar homes will be very green with lush gardens and green walls serving toom dividers and lining hallways.

PlumBing will be designed to differently handle the various kinds of effluent: toilet urine and feces; just urine; food preparation water; bath water, garden drainage, etc, We will **abandon the**

**“monotreme” plumbing system inherited from Mohenjo Daro ((a town now in Pakistan) some thousands of years ago.)**

Systems Lunans develop to keep both air and water fresh may help save Planet Earth, if we adopt them soon enough. But the rich, who control everything, live only for today (caring not for their children and grandchildren.)

That “Biosphere 2” “failed” was not due to its design but to failure to realize that the still fresh concrete of the structure’s foundation would suck oxygen out of the air in its curing process.

The same challenge will faces settlers on Mars.

## Storing **Nightspan Cold** for the **Lunar Dayspan** and **Dayspan Heat** for the **Lunar Nightspan**

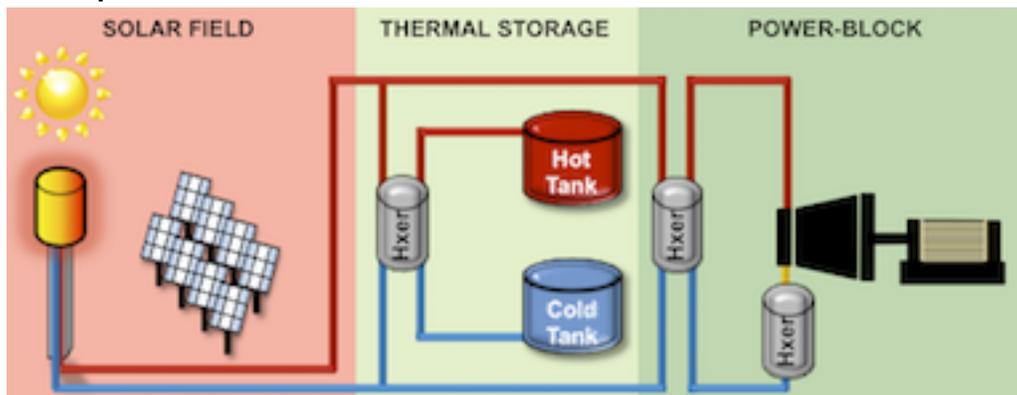
The saving feature of the Moon’s cycle of very hot dayspans and very cold nightspans is that their “averaged” temperature is temperate. **After all, the Moon, accompanying Earth in its orbit around the sun, gets the same average warmth from the sun’s rays as does Earth.**

On Mars, where we have cool to cold to very cold, that is not the case.

On the Moon, excess dayspan heat can be stored in wate tanks for heating lunar homes during the nightspan. Excess nightspan cold can be stored in thoes same tanks for cooling lunar homes during the dayspan. This is called a **“thermal storage system.”**

This is a system that does not need to be invented. But the water tanks will need to be of appreciable size to avoid reaching either a boiling or freezing situation, of course, and that will add secutity. And keep in mind, that **lunar homes. Being shielded by several meters/yards of moondust are likely to have moderate interior temperatures,** even without such sytems.

Onee versions in operation here on Earth:

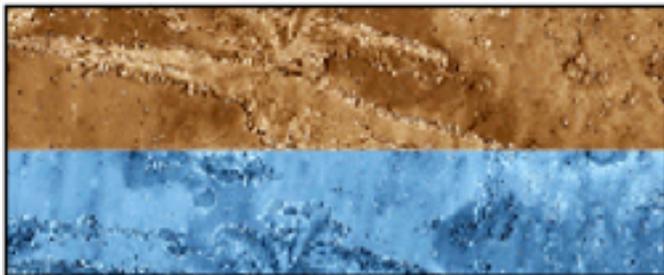


**In contrast, On Mars** where the average temperature is well below freezing, and the temprature swings about two years long there is no excess summer heat to help manage winter cold.

Mars’ seasonal temperature swings closely match those in Antarctica’s Dry Valleys

Paradoxically, many “Mars fans” have made life style choices to leave the cold Midwest and Northeast states in America fpr warmer climates in the American Southwest. What are they thinking?

**A lesson:** Mars looks like Arizona (top right below), but feels like Antactica (bottom right/left below)



Further, it takes a matter of days to ship materials and products from the Moon to Earth’s surface and to Earth orbit. The window to ship Mars-made products to Earth (and the Moon) opens evrr 790 days; ##

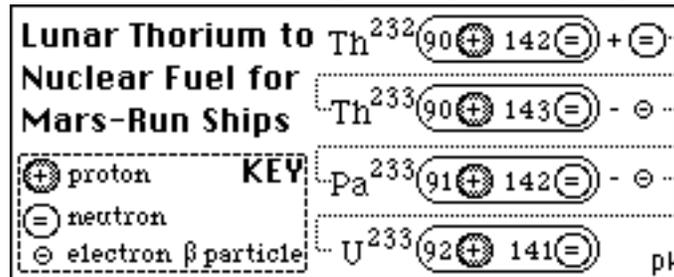
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## Some Reasons why Settling the Moon first will help Settling Mars

By Peter Kokh

- Opportunities to launch to the Moon are frequent, actually **daily**, whereas opportunities to launch to Mars using minimum-energy occur at intervals of approximately two years and two months (specifically 780 days, the planet's synodic period with respect to Earth).  
[https://en.wikipedia.org/wiki/Exploration\\_of\\_Mars#Launch\\_windows](https://en.wikipedia.org/wiki/Exploration_of_Mars#Launch_windows)

### Lunar THORIUM: Key to Opening Up Mars



#### THE TIME BARRIER TO THE OPENING OF MARS

Most Mars Mission scenarios are based on the best available current technology: chemical rockets burning liquid oxygen and liquid hydrogen. It is feasible to send a scouting expedition to Mars in this manner, even though they will need to sign waivers and releases because they will be in space “too long,” absorbing more than the recommended maximum dosage of harmful cosmic rays. The added danger of solar flares can be minimized by scheduling the flights in Quiet Sun periods which occur every eleven years. “Humans to Mars” is something most of us want very much to see, so it is tempting to be brave and cavalier\* about the nontrivial radiation risks.

\*Dr. Zubrin shows little concerned about radiation hazards during prolonged time in space (beyond Earth’s protective Van Allen Belts), or during total time spent on Mars’ surface, poorly protected by the thin atmosphere. But it serves no point to lower mission costs by dismissing the need for shielding the outpost with soil or water reserves.

Once the glory of reaching turf formerly out of human reach wears thin, fewer and fewer people will be willing to take such risks, or to spend so large a fraction of their working lifetimes doing so (3 years, say 6%). Chemical rockets are unsuitable as workhorses to open the Martian Frontier to droves of Earth-forsaking settlers and developers. Their power limitations exact a price in the coinage of time.

- Time is precious (life is too short)
- Time is expensive, adding time-indexed costs
- Time for overexposure to radiation
- Excess time discourages tourists, settlers, developers, and traders
- Excess time exaggerates difficulty of rescue, repair, replacement, resupply
- Time idle promotes boredom\*

Travelers can fill the months on board with university courses in fields where expertise will be useful on Mars, or back on home if/when they return. They can also keep busy assembling items needed on Mars that had to leave Earth in compact kits. But not everyone will find sufficient relief for boredom and cabin fever cooped up in a sardine can for six to nine months. This is not the 16th century. People of today will not care that their ancestors once spent comparable time crossing the Atlantic!

#### NUCLEAR SHIPS ALONE CAN “OPEN UP” MARS

Nuclear ships won’t be essential for an initial to land human “Kilroy Crews” on Mars, just for the political rah-rah sake of saying we did so, planting a flag, and coming home with some neat pictures and souvenir samples. But that hardly constitutes Step One toward “Opening” Mars “as a human settlement frontier”, any more than Apollo succeeded in opening up the Moon as Earth’s Eight Continent.

But unlike chemical propellants which are too quickly exhausted, nuclear fission fuels (U233, U235, and Pu239) offer the power needed for sustained high thrust, resulting in a much higher velocities. Nuclear ships can shorten transit times, extend windows, and telescope round trips, and just as importantly, cut all time-indexed costs. Nukes could cut transit time to Mars down to eighty days or so, per Stan Borowski and make Mars a nearby, viable human frontier.

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## AN ENVIRO-POLITICAL MONKEY WRENCH

Would trans-atmospheric shipment of fissionable U-233 evoke as much enviro-political concern as that of the Plutonium-239 that fuels NASA's deep space missions Galileo, Cassini (and hopefully, the Pluto-Kuiper Express)? The assumption behind this article is that, given the guaranteed irrationality of rabbleocratic political process, no distinction may be made. If not, then the dream of opening up Mars, asteroidal resources, and the Outer Solar System could die – unless! Unless we can ship unfueled nuclear engines and reactors through the atmosphere, and refine the fuel they need on the Moon.

Unless the supply of nuclear fuel throughout the Solar System is assured, there is little point in developing the engines that would use it, nor the spacecraft that would use such engines. Research on nuclear propulsion continues, primarily at NASA-Lewis, on the presumption that fuel is a non-issue.

## THE MOON CAN RESCUE THE MARTIAN FRONTIER

Lunar Prospector has been gathering data for a global geo-chemical map of the Moon and thorium is one of the elements on which it has been zeroing in. There seems to be economically minable amounts in some accessible areas. {thohr'-ee-uhm } This element is a soft, very ductile metal, silvery in color. It is in group IIIB of the periodic table, a member of the actinide series. It was found radioactive in 1898 by Marie Curie. It had been discovered in 1829 by Swedish chemist J. J. Berzelius, who named it for the Norse god Thor.

Thorium reserves contain more available energy than all uranium and fossil fuel reserves combined. Thorium-232 can be used in a breeder reactor to produce a fissionable uranium-233 through neutron absorption, in the same manner Plutonium-239 is bred from Uranium-238. The reaction sequence is shown in the page 1 graphic. (Beta decay is the "transformation" of a neutron into a proton, with the emission of an electron for charge conservation, and an antineutrino for energy and momentum conservation.)

U-233's physical and chemical properties make it much less difficult and dangerous to handle than extremely toxic Plutonium. Further, the thorium=> uranium cycle is vastly less dirty than Plutonium production. An energy amplifier reactor fueled by thorium has significant advantages:

- the reactor is essentially sub-critical
- much less transuranic actinide waste is generated
- much less radiotoxicity especially if the bred 233U and additional U isotopes are recycled
- thorium can be rendered proliferation resistant through mixing with the isotopic denaturant U-238

On the Moon there is neither air nor ground water to pollute or infiltrate. Storage of wastes in a lavatube would be cheap, easy, and absolutely safe. A lunar thorium-based nuclear fuel production operation could be highly automated. A manned station will be needed to tele-operate mining equipment, make repairs, and ship the

packaged product. Moon-based shuttles, and later, a mass driver (once the volume of demand warrants) would ship the U-233 fuel to (a) Fueling Depot(s) in one (or both) of the stable Lagrange points (L4 and/or L5, 60° {or 5 days} ahead of/behind the Moon in its orbit around Earth), conveniently outside the lunar gravity well, yet easy to reach from Earth and Moon alike.

Assuming five-day margins, nuclear rockets could offer affordable windows to Mars from 3 weeks a month from these twin "Marsgates" – for at least the major portion of the 25 month long synodic period between optimum Earth-Mars lineups. Not only will the length of trips to and from Mars be cut appreciably, but the constrictive timing of the narrow and infrequent windows would cease to choke traffic.

On its first year mission, Lunar Prospector identified the Fra Mauro region, south of Mare Imbrium and the great crater Copernicus, as notably rich in Thorium. This is the area visited in January, 1971 by Apollo 14 (the Antares with Alan Shepard, Edgar Mitchell). It is just south of the lunar equator, making a mass driver shipping operation practical.

## A REASON FOR MARS LOVERS TO LOVE THE MOON

It would seem that those driven by the vision, not just of a human scouting sciencepicnic outing to Mars, but of going beyond that to open the Red Planet as a Frontier for settlement, and as an eventual second human home world, would put thorium mining and U-233 production on the Moon near the top of their "must-do-first" list, right after development of nuclear rocket engines themselves. Yet outspoken proponents of "Mars First" seem preoccupied with doping the discussion with a list of

impatient bogus reasons to “avoid” a lunar “detour”. Lunar Thorium may be the number one utility of the Moon to the Mars Frontier constituency.

But there are other benefits that shouldn't be dismissed:

- Handier dry run equipment & procedure test-outs
- Cryogenic rocket refueling
- Manufacturing heavy components needed on Mars
- Source of willing, tried and seasoned pioneers

Just as the “Earth Problems First” crowd overlooks the possibility that the solution to some of Earth's most intractable energy and environmental problems may just lie in space, so do some “Mars First” people overlook the possibility that any of the critical prerequisites for “opening” Mars as a Frontier may involve a lunar operation. Emotions that have become almost “partisan” are getting in the way.

We are not saying that Lunar thorium will be needed to fuel nuclear power plants on the Martian surface. Mars Global Surveyor may identify similar deposits on Mars. Pioneers on Mars will duplicate the Lunar facility. Having a workable debugged operation on the Moon will make design and construction of a similar industry on Mars itself that much easier.

#### REASONS FOR MOON LOVERS TO LOVE THORIUM

A thorium-based lunar nuclear fuel industry will have benefits for lunar industrial diversification. Among many uses for thorium and thorium compounds these three promise to be especially welcome on the early Lunar Frontier.

- Temperatures
- Thorium oxide is used for high-temperature laboratory crucibles
- Glasses containing thorium oxide have a high refractive index / low dispersion – used for high quality camera lenses and scientific instruments

#### MARS RUN LUNAR THORIUM FUEL ECONOMICS

Nuclear power plant architects and engineers familiar with thorium, and chemical engineers who can figure out how to most economically extract it from lunar soils, will need to work together to come up with a set of overall designs and operation plans for such an industry before we can begin to estimate the price. It won't be high in relation to the payoffs. Those who would open up the Mars Frontier would have to pay much of the bill for creating such a thorium-based nuclear fuels industry on the Moon. Lunar developers will want nuclear power plants. So they will chip in their share. So will those who need nuclear rockets to access asteroidal resources.

Those determined to open Mars, may find no politically realistic alternative if they want to make Mars-run nuclear ships a reality. Choose not to pay the price and it may cost the dream. PK

**“For seasoned Lunan Settlers, Settling Mars will be a “Walk in the Park”**

### The DIASPORA: Where besides the Moon and Mars might Humans oneday settle?

By Peter Kokh

**MERCURY:** The north polar area has craters filled with ice, much as does the Moon. Just to the south is a basaltic mare area, like the maria “seas” on the Moon, almost certainly including lavatubes whose interior temperatures may be low enough to allow human outposts.

Besides exploration of the planet, crews could operate giant solar-powered lasers to slow incoming spacecraft and then use them to boost these ships into orbits to Mars and elsewhere in the solar system. Why, because indirect Earth to Mars by way of Mercury trips could be made more often than direct trips.

Read about it in this article: [www.moonsociety.org/publications/mmm\\_themes/mmt\\_solarsystem.pdf](http://www.moonsociety.org/publications/mmm_themes/mmt_solarsystem.pdf)

**VENUS: [Read "Rehabilitating" VENUS as a Human Destination 1992, 1998, 2000**

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

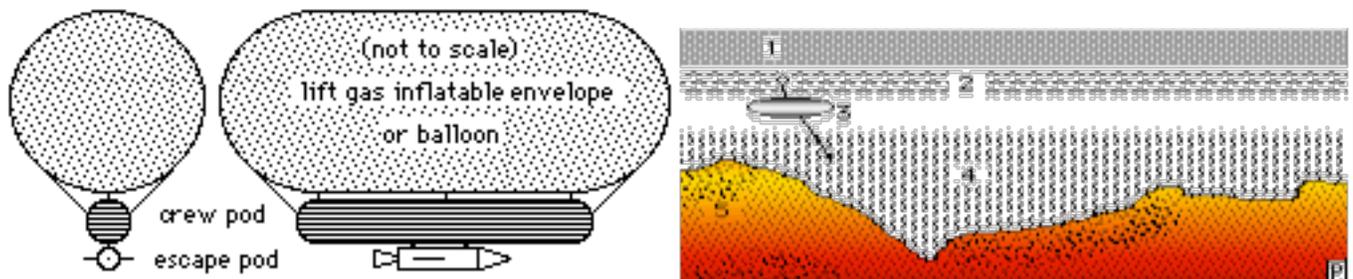
We think of Venus as a forbidding place forever "off limits" to humans. Our "twin planet" has a thick crushing atmosphere and an unsurvivable surface, abysmal lands were the temperatures and pressures far exceed all human capacity to adapt – even within technomiraculous protective cocoons.

Yet there are thinner, higher, more temperate regions in the atmosphere of this "hell planet" where the conditions are relatively benign. Such a planet-girdling pseudo "ecosphere" lacks but one thing to make it an attractive site for human outposts or settlements – "terra firma", solid land at the seemingly benign levels. But this lack is something we can, with determination, do something about. We only need to expand conservatively on the known concepts of lighter-than-air craft.

In the oxygen-rich atmosphere of Earth we would need to use helium gas for buoyancy, but as Venus' atmosphere has no significant amount of pure oxygen to cause combustion concerns, using the lighter and more buoyant hydrogen would work better. Of equal or even greater advantage is that the needed hydrogen could be mined from Venus' atmosphere locally.

Aerostats seem doable using the lightweight composite materials and fabrics now available or in the works, many of which could be fabricated in situ by mining the atmosphere itself. Venus' atmosphere has hydrogen, carbon, nitrogen, oxygen, sulfur, and possibly phosphorous and other elements present as methane, ammonia, ethane, propane, phosphine, hydrogen sulfide, carbon monoxide, acetylene, water vapor, and other compounds.

The feasibility of aerostat outposts over Venus can be tested by dropping into the upper atmosphere a pressurized crew compartment carrying an inflatable gas envelope, the lift gas with which to inflate it, and an underslung Pegasus-like shuttle by which the crew could escape to orbit.



Solar Power is not an option beneath the cloud decks of Venus. Nor are elements for fission or fusion reactors. Energy production on Venus will have to be more resourceful. Could lightning be harnessed? Circulating a working refrigerant liquid between hot lower atmospheric levels and cooler upper ones might work.

Thermal management should be a simple matter of **picking a float altitude with the right temperature**. If the outpost has excess heat to radiate, a colder and thinner altitude would provide the needed heat sink. However, radiators at the end of tethers flying above the outpost (i.e. supersats) might do the trick, especially if parking in a higher colder altitude meant being in the clouds, and losing visibility of the planet's surface.

## Industry

If all that Veneran "cloud miners" have to work with are C, O, N, H, and S -- carbon, oxygen, nitrogen, hydrogen, and sulfur -- then in addition to agricultural products (importing phosphorus and other micro-nutrients) what serviceable synthetic materials could they produce? And what sorts of things could they make from them? Structural elements from which to expand? Mere low-performance furnishings and craft stuffs? Are exotic nitrogen-based ceramics and Kevlar among the possibilities?

The fewer basic needs that can be met by self-manufacture from ambient elements, the more must at first be imported at high cost. Raw materials for manufacturing might be tele-dredged from the torrid surface.

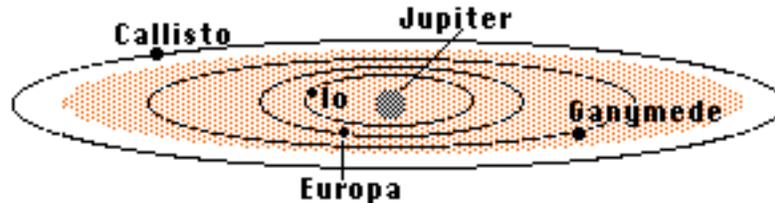
Such a facility would offer unequalled opportunities to conduct Venus science and exploration: An economic geography of the planet could be pieced together against a far future day when we might somehow be able to transform the pressure-cooker atmosphere into something humans could handle .

A down-facing observatory would map the Veneran terrain below using multi-spectral remote sensing techniques. More ambitiously, rugged oven-hardened ceramic-hulled, diamond-wired teleoperated explorers, samplers, and eventually miner vehicles, etc. might be developed to serve as our stand ins on the surface, operated by crews in the aero-xity. These could be stationary surface stations or mobile ones. Prior to this, we could begin to get our feet "hot", probing ever lower and lower as the hardness of our equipment allows, by drone airborne craft teleoperated from "The Heights".

Read the whole paper for how we might transform Venus into a livable planet: Hint: **89% of the water needed to refill Venus ocean basins is already on location**: Oxygen to be extracted from the This issue is online at: <http://legacy.moonsociety.org/international/ttsiq/> and at: [www.nss.org/tothestars/](http://www.nss.org/tothestars/)

oppressive Carbon Dioxide atmosphere, saving the carbon for an unlimited list of uses. All we have to do is import Hydrogen. Where from? From the Solar Wind of course. And you thought we'd have to find water rich comets and bring them into the inner solar system! Nope. It will be much easier. But it will be a long duration project. We predict that this is what future generations of humans will do.

### CALLISTO, GANYMEDE, EUROPA: The outer three of Jupiter's 4 larger Moons



Only Callisto orbits outside Jupiter's Radiation Belt

**CALLISTO** is the outermost of Jupiter's major moons and happily it is outside Jupiter's radiation belt. As such, Callisto will be the major outpost in the Jovian System from which missions in to Ganymede and especially Europa will be staged. Incoming ships will be jacketed in ice from Callisto's surface for protection from radiation en route to Ganymede and Europa. (We have no prediction for what manned missions to Ganymede would do)

**EUROPA's** ice crusted ocean begs to be explored, especially if surface landers find organic materials in the reddish streaks formed when ocean water below made its way to the surface when the ice cover cracked. A manned complex on the surface could be jacketed with ice on location for radiation protection.

Read: [www.moonsociety.org/publications/mmm\\_papers/europa\\_outpost\\_paper.htm](http://www.moonsociety.org/publications/mmm_papers/europa_outpost_paper.htm)



Left: an outpost on Eurp[a's ice crust could be shielded from radiation by a layer of ice blocks. Right: could there be "air" pockets under the ice?

If we find organic materials in the reddish cracks on Europa's surface, we can expect to find life of some form in the global ocean below, possibly 60 miles / 100 km deep, holding more water than Earth's global oceans! If so, we could be exploring that ocean for a long long time.

Europa-like worlds do not need to be near a sun, and could exist in any and all solar systems, even around Brown Dwarf star-wannabes. This kind of life should be predominant throughout the universe. Humans would be on Europa for a long time, studying it. But the Europa outpost population need not be large.

**TITAN and IAPETUS: Moons of Saturn** – Titan is proving to be the most unique world in the solar system, other than Earth itself. We might have a small "Space Settlement" in orbit above, controlling surface probes, even submaines with minimum time-delay, studying this unique world for a long long time.

**IAPETUS:** a moon of Saturn with half the diameter of the Moon (Earth's) is best placed for viewing Saturn's rings and as such could be the main human outpost in Saturn's system.

**URANUS:** Supposedly, Uranus has by far the largest amount of Helium-3, the ideal fuel for Fusion Reactors. If Fusion becomes a main source of power, a "Space Settlement" in orbit above the planet to control the "mining" (for want of a better word) of that Helium-3 hoard. PK

## Will we one day find evidence of past visitors from another star system?

By Peter Kokh

The possibility of past visits from explorers of other civilizations on worlds around other stars has been a hot topic for a long time – since we first realized that the stars are each “suns” and possibly host to other “solar systems.” It is hard to look up at the stars and not wonder about this possibility, especially for those of us who realize that our universe is far far older than once believed or taught.

That the Sun, formed 4.6 billion years ago, as ancient as it would seem to us, did not form from a collapsing nebula until our host galaxy, the “Milky Way” was already about 8 billion years old, suggests that other civilizations on worlds around other suns, may have arisen far earlier.

It is likely then, that there are, or have been, other civilizations that have risen before ours, and which may or may not have survived into our times. Yet we must never forget that when we look at the stars we are seeing them as they existed years, even hundreds of years, even thousands of years, even millions of years in the past. If we were to “find” evidence of a civilization, we will have no ground to be sure that this civilization still subsists.

Undoubtedly, some civilizations will endure longer and reach higher levels than others. Our own civilization’s future is far from assured. We are in that juvenile stage where we are living for the present, and carelessly letting our biosphere deteriorate, putting our own comforts ahead of those of generations to come.

### “Interstellar conversation” is quite impossible.

That it would take a message from another civilization years, if not centuries, even millenia, even millions, hundreds of millions of years to reach us, and just as long for our answer to reach them, it should be clear that “interstellar conversation” is quite impossible.

### Calling Cards

But could an interstellar-faring civilization have left a calling card in our system in the hopes that the ecosystem on Earth would mature to the point of giving birth to an intelligent species and an inquisitive civilization such as ours? It is marginally possible.

Where would they have left a calling card, and what would it say.

We’ve written about this before. The visitors would have had to pick a place that could survive intact for millions, even hundreds of millions, even billions of years. No place on Earth fits that requirement.

What about the Moon? Yes, but a calling card left on the surface would erode over time. And if not, it could be found before we are “ready” to appreciate it.

The Moon’s lavatubes, those that have not collapsed into rille valleys, have been around for billions of years. Some of them have collapse holes caused by meterite impacts, inviting human explorers to explore. To date, we have found several such holes.

### What might they have left behind for us to discover and appreciate?

Certainly not the secrets of interstellar travel! Maybe something about themselves.

But far more usefull and appreciated would be an exhibit of some kind showing us **what Earth looked like – in detail – at the time of their visit.** Could we think of a more useful gift? Views of Earth, showing the then placement of the continents, forests, deserts, etc. And maybe a comprehensive exhibit of the plants and animals that existed at that time. Such knowledge would fill in a lot of gaps in the picture we have of Earth’s past, not only filling in gaps, and perhaps correcting some assumptions..

### The “Cheshire Cat” – leaving us their smile

They might also tell us something about their own home sun, at least the direction in which it lies, maybe the distance, about their own biology, and what their diverse animal and plant life are like, etc.

But it would be best if they did not tell us much about their culture and history. It would also be best if they left us no technological shortcuts to our own future, letting us to discover such things on our own.

Once we are able to broadcast to other civilizations around other stars, messages that may reach them far in our own future, let’s hope we take a similar “Cheshire Cat” approach. ##

## Peaceful Uses for Death at the Speed of Light

By Madhu Thangavelu

SpaceNews Commentary, June 20, 2016

At the Nuclear Security Summit in Washington this spring, U.S. President Barack Obama reaffirmed the United States' commitment to nuclear disarmament, nuclear nonproliferation and strengthening nuclear security worldwide to prevent nuclear weapons and enriched materials from falling into the hands of terrorists and other non-state actors.

It's been 71 years since the detonation of the first nuclear weapon. Humankind, far from becoming a less belligerent species, is crafting 21st Century weapons of increasing efficiency, precision and lethality. A new generation of smaller nuclear warheads are being developed with the goal of achieving an arsenal that's easier and cheaper to maintain, while research continues into newer inventions such as expendable drones and other, much more sophisticated robotic fighting machines.

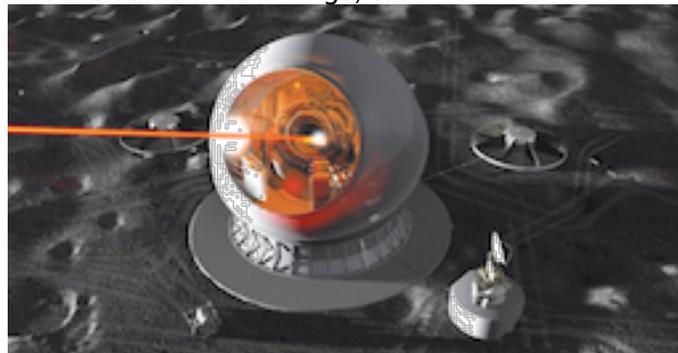
At the World Economic Forum in Davos, Switzerland in January, speakers sounded the alarm about the impending rise of combat robots bestowed with artificial intelligence yet lacking the on-the-fly judgment human soldiers bring to the battlefield. Lasers, a ubiquitous technology that has found rich and varied use in such diverse areas ranging from fundamental science and astronomy to medicine, communications and consumer electronics are now being shaped for war. With rapid development in high density power storage and greater portability, high energy lasers are coming of age and could soon become the battlefield weapon of choice. High energy lasers (HEL) — are part of a broader category of directed energy weapon systems that also included kinetic and acoustic devices — are now being tested for battlefield application.

Think light sabers and laser blasters, except that the action is invisible, instantaneous and very lethal. Mounted on warship, aircraft, and ground vehicles, lasers offer many advantages over conventional artillery including rapid target acquisition, point-and-shoot capability, and low operational cost. The snipers and infantry of tomorrow may very well carry deadly accurate laser guns running off power sources that fit in their backpacks.

Ongoing tests show that HEL systems today are approaching the capability to destroy targets hundreds of miles away, and all this without firing projectiles — just intense, lethal beams of energy at the speed of light. Straight forward line-of-sight ranging, target acquisition, quick friend or foe verification, instantaneous and highly reliable lock-on and target engagement, as well as immediate damage assessment and reengagement all become possible with lasers.

Sophisticated optical technologies such as beam combining and phased arrays with multiple, lowerpowered laser modules ganged together can deliver lethal power to targets far away. Anything you can see through a high-power telescope suddenly becomes a viable target. Adaptive optics, routinely used in groundbased astronomy, could be used to compensate for atmospheric distortion effects and technologies are being perfected to narrow losses due to phenomena like thermal blooming, produced by the scorching heat of the laser beam.

The power that HEL systems can deliver to the target is so intense that the thrust from the resulting plume of vaporized material act like rocket jets, resulting in an abrupt physical shock that pounds the target with the reactive force of Thor's hammer. As with all deadly powers that mankind discovers, invents and wields — amid all the wicked warfighting uses, with all the gloom-and-doom dark clouds in the horizon — there are some silver linings, too.



The author's concept drawing of an asteroid busting high energy laser complex on the farside of the Moon. Credit: Courtesy of Madhu Thangavelu

Recently, a small laser mounted on NASA's Lunar Atmosphere and Dust Environment Explorer spacecraft, was able to transmit data to Earth at 600 megabits per second — a rate far superior to regular radio frequencies normally used for space missions, heralding a new era in low-power, wide-band civilian space communication. Several other space-based laser systems are being proposed and tested for interplanetary and deep space communications.

Among other concepts for using lasers in space, NASA is studying laser propulsion as a way to overcome the speed barrier posed by conventional chemical rockets. Recent literature suggests using lasers to power spacecraft to velocities approaching 10–20 percent the speed of light using lasers — a prospect that bodes well for new interstellar probe missions.

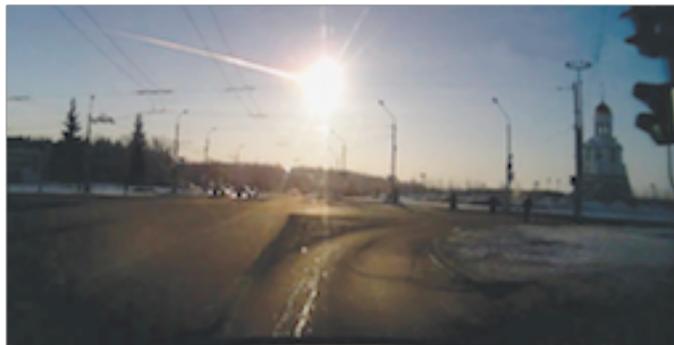
HEL systems can be an effective tool for removing orbital debris. There are some ideas on mounting such a system on the International Space Station to clear its orbital track of incoming debris. And as we design larger and faster spacecraft to shorten interplanetary transit times, and since impacts with natural debris are far more energetic at higher velocities, a laser cannon could become a vital system for keeping the spacecraft's trajectory clear.

High energy lasers could be one very effective arrow in our quiver for another progressive and peaceful humanitarian use: Planetary Defense. The technologies, strategies and global policy governing ways to thwart an asteroid or cometary fragment from colliding with Earth and causing a cataclysm is now being addressed at the United Nations as well as among the spacefaring nations of the world. We have the technological and operational know-how to start mitigating such extraterrestrial threats. The forces of nature are so great that we are able only to engage a narrow range of potentially hazardous objects at this time. At the request of Congress, NASA is scaling up budgets for Planetary Defense every year. And work is ongoing on improving sensors that can detect hazardous objects early to provide enough warning.

The earlier we detect them, the more time we have, to ready and field threat-mitigation systems. The further out we detect and ascertain the threat, the less energy we need to nudge them out of an Earth collision path. But even so, given the energies needed to thwart collision with large objects, most of the current planetary defense strategies involve early detection — years in advance — in order to gradually nudge the threatening object off its collision course with Earth. Unfortunately, the precise impact region cannot be accurately pinpointed until a few months or weeks before impact.

Whether we should even intervene if the impact is projected to occur over unpopulated areas, such as deserts or oceans, is a matter of some debate. After all, we now know that impacts and so-called air bursts — where the object vaporizes in the atmosphere, dissipating most of its energy while creating an intense and deadly shock wave with the capacity to cause widespread havoc were they to occur over cities — happen with disconcerting frequency, albeit (so far, at least) in remote regions and with no consequence to civilization or the biosphere.

But as populations grow and new cities rise up around the world, humanity faces the potential of just such a tryst, with all the more probability, as we saw in Chelyabinsk, Russia, in 2013. Without warning, an airburst damaged buildings and shattered windows, leaving over 1,400 people needing medical attention. Unlike hurricanes and other natural disasters that we can see coming, without early detection assets in place, asteroid impacts offer little advance notice, though we are improving our assets to detect and warn of such events.



A driver's dashboard camera captured this image of a meteorite streaking across the sky before exploding above the Central Russian city of Chelyabinsk the morning of Feb. 15, 2013, causing widespread property damage and personal injury, although no deaths. Credit: Wikipedia

A recent chart from NASA's Center for Near Earth Object Studies at the Jet Propulsion Laboratory clearly shows that our planet is being bombarded by potentially hazardous objects more frequently than previously estimated. NASA has begun a series of International Planetary Defense workshops and JPL now hosts the Planetary Defense Coordination Office for NASA to bring together the various data gathered from diverse organizations, including the International Asteroid Warning Network and the European Space Mission Planning Advisory Group. Even the U.S. Federal Emergency Management Agency is now involved in studying how to handle asteroid impact aftermath issues. And a series of international Planetary Defense Conferences hosted by the International Academy of Astronautics continues to draw attention to this issue with global consequences, seeking ways to make nations aware of the threat while continually updating progress in both technologies and policy. The University of Southern California, where I teach, presented their case called Eden Shield at the 2015 conference.

What if we are faced with a threat that requires a response at short notice? This is a question that was posed to a group of young professionals at the International Space University's Space Studies Program held last summer at Ohio University. In their report titled "READI: Roadmap for Earth Defense Initiatives" students from around the world surveyed the topical literature, quizzed experts during their nine-week intensive program, and concluded that high energy lasers offer a new way to tackle just such a threat. Comets, much more lethal than asteroids, composed mainly of water ice, are particularly vulnerable because lasers can easily sublimate them. Modulating the laser beam could also cause resonance excitation on monolithic asteroids, fracturing them and rendering the smaller fragments easier to deal with, to avoid serious impact damage.

But putting up such deadly systems in space pose serious policy issues since they could be turned toward the Earth. Therefore, the far side of the Moon — which never faces toward Earth — could be an ideal site to host such a system.

In Hindu mythology, Lord Shiva's third eye was used in anger, like a laser, to incinerate. In reality, as we quickly approach the threshold of technologies that allow us mastery of weapons that make us the purveyors of death at the speed of light, it warms the soul to see a silver lining in those dark clouds on the horizon. Like the double-edged sword of nuclear technology in the 20th Century, there are peaceful, humanitarian uses for this deadly 21st Century high energy laser technology that makes us both purveyors of death at the speed of light and the protectors of our species and stewards Earth's biosphere from external threats like asteroids and comets. ##

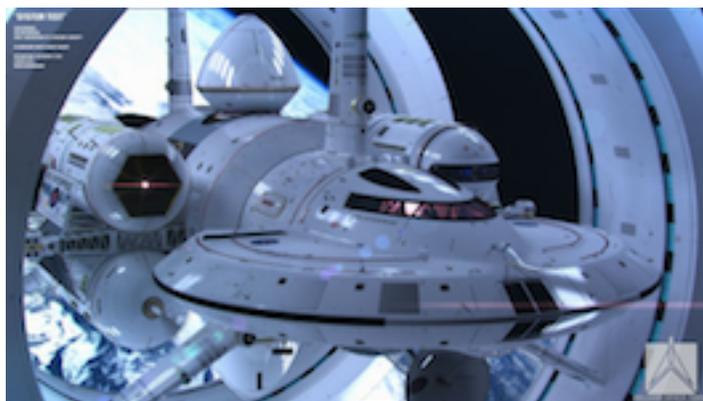
**Madhu Thangavelu** teaches the graduate-level Space Exploration Architectures Concept Synthesis Studio within the University of Southern California's Department of Astronautical Engineering and is a graduate thesis adviser in the School of Architecture. ##

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**Note: David Dunlop**, a regular contributor, sent us a couple of articles before departing for Guadalajara, Mexico for this year's. Astronautical Federation's **International Astronautical Conference**, September 26th – 30th 2016. (Oh, how I would have loved to attended!)

Unfortunately, both articles arrived "garbled" for some reason, and we were unable to "degarble" them. Hopefully, they will appear in the next (and last) issue, TTSIQ# 18, due out the end of December.

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One NASA idea for a warp drive interstellar spaceship. It's a concept based on the equations of Dr. Harold White—lead at NASA's Eagleworks Advanced Propulsion Physics Laboratory.

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

## 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)

### Fall 2016 issue

- 12 **IMeet me in St Louis at ISDC 2017** – Gloria Llyod
- 16 **How to Train your Dragon to Land on Mars** – John F. Kross
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[www.MMM-MoonMinersManifesto.com](http://www.MMM-MoonMinersManifesto.com)

### AUGUST 2016 – MMM #297

- 2. In Focus: Between “suburban” Earthside Moon: Geosynchronous Orbit Activities could be Earth’s Economy
- 3. Building-out GEO with Materials from where on the Moon? Two Options, Peter Kokh.
- 4. Making Heavy Equipment on the Moon, Dave Dietzler
- 6. A Brief Assessment of Regolith Processing Systems, Dave Dietzler
- 7. Space Solar vs. Elon Musk’s Rooftop Solar, Dave Dietzler
- 8. Book Review: A Case for the Moon by Robert Walker

### SEPTEMBER 2016 – MMM #298

- 2. In Focus: The “Megapolicene” Era has begun – not good news! – Peter Kokh
- 3. Analog Moon/Mars Habitats in a Rotating Double Torus in GEO, Peter Kokh..
- 5. Tourists will “Pay their Way” to help Build Lunar & Martian Outposts, Peter Kokh
- 6. Settler Artists, Crafts, and Sports will lure Visitors & Settlers to the Moon. Peter Kokh
- 7. Moon Tourist Opportunities Illustrated, Peter Kokh
- 8. Productive, Educational Activities on the months long trip out to Mars, Peter Kokh

### OCTOBER 2016 – MMM #299

- 2. In Focus: The role of “Space Settlements
- 3; Space Settlement Pictures and Designs;
- 4. Improving the Livability of Space Settlements
- 5 Beyond L5: Where Space Settlements” would be helpful
- 6 Space Settlements as Interstellar Arks; Space Settlements as Space Hotels in Earth Orbit
- 7. Space Settlement Metroplexes
- 8. The National Space Society’s annual Space Settlement Design Competition.

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



## 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.planetary.org>

The Planetary Society has many initiatives:

“exploring the skies for dangerous asteroids, hunting for Earthlike planets, searching for life in the universe, Advocating for needed science funding, flying its very own solar sail spacecraft, Lightsail 1.”

## 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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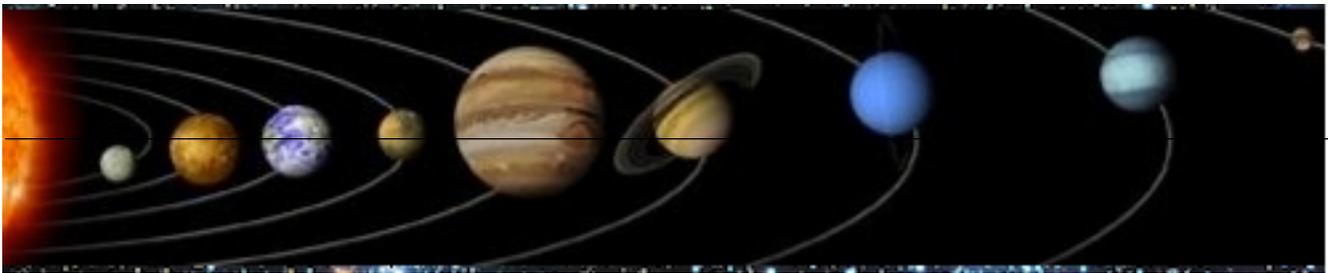
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## The Stars International Quarterly #17

**The next issue, TTSIQ #18, due the end of January 2017, will be the last.**

I have very much enjoyed putting together *To The Stars International Quarterly*, and its predecessor, *Moon Miners’ Manifesto India Quarterly* for the past several years. As to *Moon Miners’ Manifesto* itself, the coming December issue, #301, the 30<sup>th</sup> anniversary issue, will be the last. I am retiring to work on two books, proposed titles:

“A Pioneer’s Guide to the Moon”

“The Future Factor: what makes the universe tick, and everything in it.”



But, I will also be introducing a new publication: “*Outbound: the Moon, Mars, and Beyond.*” no schedule, no set format, no set length, and it will be available in pdf file format only. In addition to new articles and news comments, “OMMB” may also include a list of links to select news items: a short form of TTS. How to get OMMB? To be tittle. Stay tuned. - Peter Kokh

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