



India's ISRO successfully launches its own cryogenic rocket, joining 5 other nations.

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List of Recent Feature Articles in Our Sister Publications: **Ad Astra, Moon Miners' Manifesto**

## 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 former 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 annual 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 our society, providing room and resources for the growth of the human race without despoiling Earth, and 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 which promotes the exploration and development of space by educating people about the benefits of space, through 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.

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



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



## SPACEPORT NEWS

## ANALOG FACILITY TRAINING

### Bigelow Aerospace seeks people to test livability of Inflatable Space Modules

<http://www.bigelowaerospace.com/CVSScrewmembers.php>



#### **Duty Location: North Las Vegas, Nevada**

Bigelow Aerospace seeks mature, well adjusted adult individuals with backgrounds in the social, psychological, behavioral, biological, nursing, engineering or crew systems sciences for astronaut-in-space simulation studies.

#### **Qualifications:**

Demonstrated expertise in detailed report writing with requested education background below.  
US Citizens and Permanent Residents Only

#### **Responsibilities:**

The successful candidates will be expected to spend 8, 16 or 24 hour periods in a closed volume spacecraft simulation chamber. Candidates will live (eat, sleep and exercise) inside the chamber for defined periods of time and will be monitored continuously.

**Successful candidates** will be given structured daily tasks and schedules and will be expected to produce detailed daily reports on their activities and on their interactions with other crew members. The candidate will implement Bigelow Aerospace programs for quantifying, evaluating and optimizing crew systems, including process efficiencies, program quality and reporting on psychological, existential, social and environmental factors in spacecraft crews.

#### **Education:**

BS or MS in Social, Psychological, Behavioral, Biological, Nursing, Engineering, or Human Factors Sciences.

**How to apply:** See link above. ##



## Simulating Long Duration Space Missions on Mauna Loa, Hawaii

<http://www.spacecalendar.com/march-24-30-2014-vol-33-no-12-hawaii-island-usa/>

Moon and Mars mission studies continue on Hawaii Island slopes of Mauna Kea and Mauna Loa, near-perfect analog sites for Lunar and Martian environments to test life support systems, robotic prototypes, dust mitigation tactics and in-situ resource utilization.



Hawai'i Space Exploration Analog and Simulation (HI-SEAS) Mission 2, lead by University of Hawaii Manoa under a US\$1.2M award from NASA, will have a crew live at ~2,500-meter (8,200-foot) altitude in an abandoned quarry on the northern slope of Mauna Loa from March 28 to July 28. The dome habitat (used in HI-SEAS Mission 1 food study) is 11-meters in diameter enclosing a volume of 384 cubic meters.

Researchers will monitor crew communications, workload, job-sharing and conflict resolution over the course of the mission to recommend strategies for crew composition and support during long duration space missions. Each crew member will complete a personal research project that may involve biological or geological field research, engineering design and technology evaluation, scholarly writing or artistic endeavors. An 8-month space mission is planned for August 2014 and a 12-month study June 2015. ##

## NEW ROCKETS

### ISRO Successfully Launches Indigenous Cryogenic Engine-Powered GSLV-D5

[http://articles.timesofindia.indiatimes.com/2014-01-05/india/45881908\\_1\\_cryogenic-stage-isro-chairman-k-radhakrishnan-gslv-d5](http://articles.timesofindia.indiatimes.com/2014-01-05/india/45881908_1_cryogenic-stage-isro-chairman-k-radhakrishnan-gslv-d5) - <http://www.bbc.co.uk/news/world-asia-india-25618258>

<http://www.dnaindia.com/india/report-gslv-launched-successfully-increasing-india-s-clout-in-outer-space-technology-1945988>



JAN 6, 2014 - India's ISRO has become the sixth space agency in the world to use an indigenous cryogenic engine to launch heavy satellites, joining the United States, Russia, France, Japan, and China

ISRO's Geosynchronous Satellite Launch Vehicle (GSLV-D5), powered by a cryogenic engine, blasted off from the Satish Dhawan Space Centre in Sriharikota in southern Andhra Pradesh, and put a 1,982-kg GSAT-14 communications satellite into orbit after a 17-minute flight. The successful launch comes after several failed attempts. The rocket's payload capacity is 2,500 kg, 2.5 metric tonnes. ISRO had been experimenting with cryogenics for two decades. Two attempts in April and December 2010 were unsuccessful. This successful launch gives India the ability to put satellites weighing more than two tonnes into orbit using cryogenic propellants (liquid oxygen at minus 183C and liquid hydrogen at minus 253C.) #



## SpaceX to Launch Dragon to ISS, Test Falcon 9 Landing Legs

<http://www.spacecalendar.com/march-10-16-2014-vol-33-no-10-hawaii-island-usa/>

Space-X is set to launch its Dragon spacecraft on the 3rd ISS cargo delivery mission (CRS 3) aboard the upgraded Falcon 9 v1.1 rocket on March 16 from Cape Canaveral Space Launch Complex 40.

**Working toward full reusability, this launch will test 4 landing legs attached to the first stage.** After separation from the 2nd stage and payload, 3 engines in 1st stage will relight for a **supersonic retropropulsion burn**, then perform a landing burn to stabilize and decelerate the stage over the ocean and ~10 seconds later deploy the landing legs. There is a 30–40% chance of recovering the first stage.



Above: legs folded against sides of booster

“Space “experts” have considered such a feat impossible. But Musk continues to amaze everyone with his ingenuity and readiness to explore new territory. If recovery of first stage rockets is possible, it could bring down the cost of delivery to orbit considerably. SpaceX is set to launch at least 2 additional Dragon CRS missions this year, and continues upgrading Dragon to carry humans into space – first piloted test flight expected before the end of 2015. ##

## REFUELING DEPOTS IN SPACE

### Storing Extra Rocket Fuel in space for future missions?

<http://www.scientificcomputing.com/news/2014/03/galactic-gas-station-mit-team-proposes-storing-rocket-fuel-space>

March 6, 2014 – Source: Massachusetts Institute of Technology

#### Summary:

Future missions to the Moon may be fueled by gas stations in space. A spacecraft might dock at a propellant depot, somewhere between the Earth and the Moon, and pick up extra rocket fuel before making its way to the lunar surface. Orbiting way stations could reduce the fuel a spacecraft needs to carry from Earth -- and with less fuel onboard, a rocket could launch heavier payloads, such as large scientific experiments, at considerably less total expense.

Over the last few decades, scientists have proposed various designs, such as building a fuel-manufacturing station on the Moon and sending tankers to refill floating depots. But most ideas have come with hefty price tags, requiring long-term investment.

The MIT team has come up with two cost-efficient depot designs that do not require such long-term commitment. Both designs take advantage of the fact that each lunar mission carries a supply of “contingency propellant” — fuel that’s meant to be used only in emergencies. In most cases, this backup fuel goes unused, and is either left on the Moon or burned up as the crew re-enters the Earth’s atmosphere.

The MIT team proposes **using contingency propellant from past missions to fuel future spacecraft**. A mission returning to Earth, could drop a tank of contingency propellant at a depot before heading home. The next mission can pick up the fuel tank on its way to the Moon as its own emergency supply. If it ends up not needing the extra propellant, it can also drop it at the depot for the next mission — an arrangement that the team refers to as a “steady-state” approach.

[For the rest of the article, go to the link above

**Editor.** Such a depot could be placed at the Earth–Moon L1 position where Earth and Moon gravity is neutralized. However, unlike the L4 and L5 points which lie in a gravitational “valley” and need no station-keeping, L1 in front of the Moon (and L2 behind the Moon) are on gravitational “crests” and objects placed there need station-keeping fuel to keep from drifting away. So the question is, what percentage of the stored reserve fuel must be used for station keeping, and how much will be left for refueling. That would seem to depend on the amount of traffic and its frequency. The more traffic the more “contingency fuel” might be left for refueling. But this is a complex issue.

**Additional reading:**

<http://hyperphysics.phy-astr.gsu.edu/hbase/mechanics/lagpt.html>

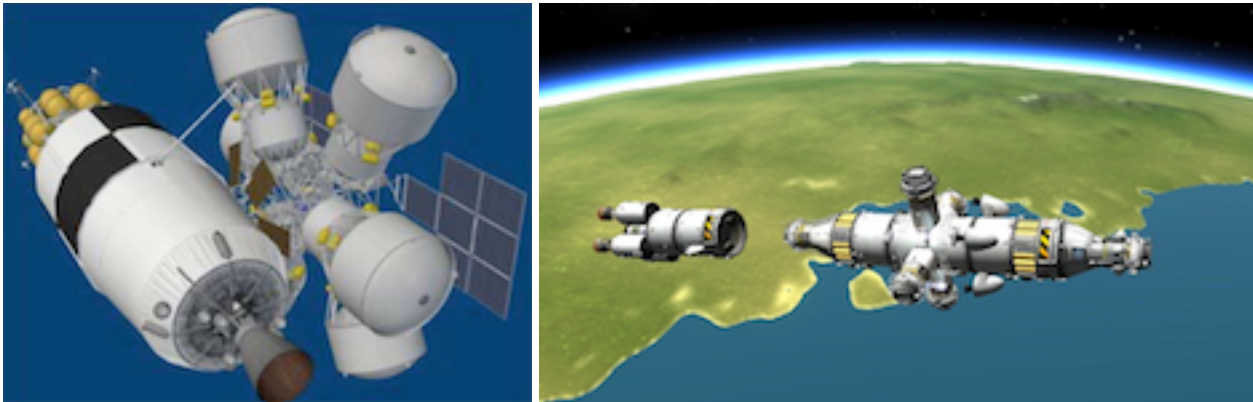
<http://www.slideshare.net/jongoff/sa08-prop-depot-panel-dallas-bienhoff> (in low Earth orbit)

[http://en.wikipedia.org/wiki/Propellant\\_depot](http://en.wikipedia.org/wiki/Propellant_depot)

<http://www.nss.org/articles/depots.html>

<http://www.space.com/3644-prototype-satellites-demonstrate-orbit-refueling.html>

**Images:**



## ASTRONAUTS

### “Gagarin: First in Space” – Film Trailer – in Russian, English subtitles

<http://www.youtube.com/watch?v=-ya6tGohRlw>

### An Astronaut’s Rhythm – “Jetlag” and other issues

[http://www.esa.int/Our\\_Activities/Human\\_Spaceflight/Astronauts/An\\_astronaut\\_s\\_rhythm](http://www.esa.int/Our_Activities/Human_Spaceflight/Astronauts/An_astronaut_s_rhythm)

[There is a silent video, the ever changing view of Earth as the Station passes overhead]

6 January 2014 – If you have flown long E<>W distances, you will be familiar with the jetlag that comes with traveling across time zones. Our body clocks need time to adjust to different daylight times. But what about astronauts? Do they suffer from rocket-lag?

Astronauts can suffer sleeping problems in space just as on Earth. can all upset their body clocks. Minimising such sleep disturbances as stress, heavy workloads, anxiety, background noise, light and air quality is just one of the goals of the European Astronaut Centre’s medical team.

“As on Earth, there are three basic ways to help settle into a regular sleeping pattern,” notes Volker Damann, head of the space medicine office. ISS “astronauts have a very structured day, working ten hours maximum followed by a sleep period of eight hours. Breakfast, lunch and dinner are at set times as well as relaxation periods, debriefings, times to communicate with family and friends, times for privacy and times for sports activities.” The schedule is a 24-hour Earth day synchronised to Greenwich Mean Time [London Time with no relation to 16 sunrises and sunsets every 24 hours on Earth below.

After a Monday–Friday workweek, Saturday is spent on more work, maintenance, cleaning and private time, while on Sunday they have no duties at all, although many astronauts continue to perform voluntary science and maintenance.

The space medical community is experimenting with light of different colours. Morning and evening sunlight on Earth has more red in it, while bright sunlight during the day has more blue wavelengths, cueing our body for the time ahead.



### Blue lighting on the Space Station could influence the body to be more alert, whereas red lighting might induce sleep.

“Medication is a last resort as side effects include drowsiness and difficulties on waking up. The Astronaut Centre tests medications for side-effects because they can differ between astronauts. Typical sleep medication induces sleep but is quickly filtered out by the body. “

“Space pharmacology is still in its infancy. Nobody really knows how drugs work in weightlessness and whether a typical dose on Earth will be too little or too much in space. European researchers are investigating this area so astronauts can sleep soundly knowing that the people on ground are looking out for them.”

## Astronaut 'Skinsuit' Could Soothe Zero-G Backaches in Space

January 16, 2014 – <http://www.space.com/24301-astronaut-skinsuit-soothes-space-backaches.html>  
<http://www.space.com/24850-astronaut-astroskin-antarctic-expedition.html>



**L:** This high-tech "skinsuit" for astronauts is a tailor-made overall with a bi-directional weave specially designed to counteract the lack of gravity to help avoid backaches. It squeezes the body from the shoulders to the feet with a similar force to that felt on Earth.

**M:** An astronaut "skinsuit" concept undergoes weightless testing in a microgravity research flight. The skinsuit is a tailor-made garment designed to squeeze an astronaut's body to help counteract the lack of Earth's gravity in space.

**R:** This high-tech "skinsuit" for astronauts is a tailor-made overall with a bi-directional weave specially designed to counteract the lack of gravity. Here, the force the suit is producing is being measured at the feet with a computer using force transducers in the soles of the "footwear.kinsuit" could help astronauts combat the back problems that are a common consequence of long-term spaceflight, researchers say. NASA

Individual astronauts "grow" as much as 7 cm (2.75 in) during space missions as their spines stretch in microgravity — a change large enough to cause significant pain. The problems often continue back on Earth, as astronauts have a high chance of suffering a slipped disk, getting back into shape.

ESA hopes the new skinsuit will make off-planet living much more comfortable by counteracting the lack of gravity. The suit features a **bi-directional weave that squeezes the body from the shoulders to the feet, mimicking the gravitational force felt on Earth.** Getting the suit to fit correctly was challenging. The suit must be both tight-fitting and comfortable to wear, providing the right amount of pressure in the right places.

ESA and researchers from Kings College and University College in London and the Massachusetts Institute of Technology in Boston are testing skinsuit prototypes, currently made of spandex. The plan is to flight test the suit in 2015, with ESA astronaut Andreas Mogensen wearing it aboard the Station.

The suit could have applications on Earth. It could help elderly and many people with lower-back problems. This technology might also improve the support garments for victims of cerebral palsy. ##

## Turning Urine into Clean Water on the Space Station

<http://www.space.com/25193-astrobotic-tests-robots-under-different-gravity-video.html> –VIDEO

## RADIATION PROTECTION FOR HUMANS

### 25th Space Radiation Workshop Focuses on Human Space Flight

<http://www.spacecalendar.com/february-10-16-2014-vol-33-no-6-hawaii-island-usa/>

Feb 11–13, 2014 – The 25th Annual NASA Space Radiation Investigators' Workshop with the theme '**Challenges and Opportunities: Maximizing Human Space Flight Research**' was held in Galveston, TX.

Active researchers in the Space Radiation Program interacted and shared their results with scientists in the Human Research Program and discussed future program directions. Principal Investigators gave presentations under Human Research Program categories of

- Behavioral Health and Performance
- Exploration Medical Capability
- Human Health Countermeasures
- Space Human Factors and Habitability
- **Space Radiation.**

John Norbury (L) of Langley Research Center will chair 2 sessions on 'Physics and Space Technology' and David Kirsch (C) of Duke University chaired 'New Investigations – Space Radiation.' According to Dr. Cary Zeitlin, PI for the Martian Radiation Environment Experiment, the average yearly dose of galactic cosmic radiation (GCR) on Earth is 0.3 millisieverts (radiation from all sources equals 3.6 millisieverts).

The average yearly GCR dose during cruise to / from Mars equals 657 millisieverts. Dr. James Logan (R) stresses "the standard approach just won't cut it for extended missions beyond Earth orbit... considerable strategic vision, innovation and resources [are required]... once these new realities are taken into account, where we should go, how we should get there and why do it at all will become more and more obvious." ##

### Comparing Identical Twin on the Ground, to the Other on ISS, after 1 whole Year

[www.space.com/24990-one-twin-in-space-one-on-the-ground-boon-for-science-video.html](http://www.space.com/24990-one-twin-in-space-one-on-the-ground-boon-for-science-video.html)

<http://www.space.com/24985-nasa-identical-astronaut-twins-science.html>



**Mark and Scott Kelly**, identical twins, and both astronauts, have been with NASA for some time now. Mark, husband of former Congresswoman Gabrielle Giffords, a victim of gun violence, has been retired since that incident. Scott remains on duty.

This gives NASA the opportunity to compare the effects of long term zero-g on the human body as well as on behavior. Scott will spend a full year aboard ISS, and the before and after effects will be studied in comparison with Mark who will remain on Earth. This method will identify those changes due simply to aging in comparison to those due to absence of gravity. Ten experiments will be involved.

What is due to Nature, what to environment? Watch the (2) Videos.



## MANNED SPACECRAFT

### Commercial Space Travel Training Company Gets FAA Approval

<http://www.space.com/24469-commercial-space-travel-faa-approval.html>

January 29, 2014 – Do you want to fly a suborbital space plane? A rocket launch all the way into orbit? A new commercial spaceflight training company wants to help you develop the right stuff for flying to space.

**Waypoint 2 Space** — a Houston-based company aimed at helping commercial astronauts train for spaceflight — has received Federal Aviation Administration safety approval to train would-be astronauts. Company officials hope to start training commercial space pilots for private trips to space this Spring.

#### People holding tickets aboard a private spacecraft or space fans interested in leaning how to fly to space can buy a training package.

This is an important milestone for the commercial spaceflight industry. "The FAA is working very hard to assure that space vehicles, launch sites and training programs are the safest they can be." \ Waypoint 2 Space is their first. They have 300 slots available for training starting this April.

#### Spaceflight training isn't cheap.

- A one-week "spaceflight fundamentals" program costs \$45,000. Full trips to space on Virgin Galactic's SpaceShipTwo are \$250,000 a ticket.
- Zero Gravity Corporation, offers weightless trips on a modified jet for about \$5,000 per trip.

The spaceflight fundamentals program is one of three commercial spaceflight training options offered by Waypoint 2 Space, designed to give participants a taste of what spaceflight is like, taking candidates through g-force training, a history of spaceflight, microgravity training and other kinds of courses needed for flying to space.

The company also offers specific suborbital training for flights aboard a space plane — like Virgin Galactic's SpaceShipTwo. But registration is only available for service providers.

A third Waypoint 2 Space program starting in 2015, is for orbital spaceflights. Wait list reservations open next year, in 2015..

The Waypoint 2 Space team is a planned mix of individuals who have developed training programs for both NASA astronauts and Air Force pilots. The training programs incorporates the best techniques and technologies from NASA and Air Force programs. ##

### India Unveils its home-designed and built Astronaut Capsule

<http://news.sciencemag.org/asiapacific/2014/02/india-unveils-astronaut-capsule>

**NEW DELHI**—India is aiming to become the fourth nation to send humans into space. ISRO unveiled the **outer skeleton** of locally made and developed manned space capsule, The plan is to launch the manned space capsule on its first experimental flight Geo-synchronous Satellite Launch Vehicle Mark III (GSLV-MK3) as early as May or June this year. The rocket is capable of lifting 10 tons into a low-Earth orbit.



The design differs somewhat from original sketches

#### Next, the first flight with a vyonaut on board

ISRO seeks \$2.5 billion from the government for a human space flight program designed to launch Astronauts into space 7 years after final approval is given. But so far the administration committed to only \$36 million for the development of critical technologies needed.

The capsule, fabricated by Hindustan Aeronautics Limited (HAL), is designed for a weeklong space mission carrying two or three astronauts in a low-Earth orbit. No human or animals will be aboard the capsule during the coming initial test. ##

## Spacecraft Hull-crawling Robots

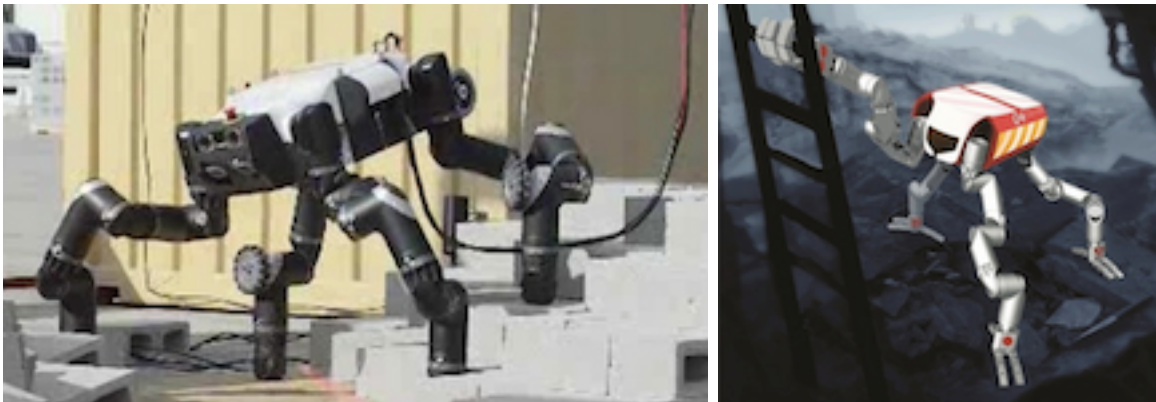
[www.space.com/24396-spacecraft-hull-crawling-robots-are-these-their-ancestors-video.html](http://www.space.com/24396-spacecraft-hull-crawling-robots-are-these-their-ancestors-video.html)

Way cool! This is a must-watch video!

## PROGRESS IN ROBOTICS

### NASA Jet Propulsion Laboratory (JPL) “Robo-Simians”

<http://www.space.com/24286-nasa-robosimian-space-robot-photos.html>



The Jet Propulsion Laboratory's official entry, **RoboSimian**, is seen in this image as it awaited the first event at the DARPA Robotics Challenge in December 2013. "Clyde" is four-footed but can also stand on two feet. It has four general-purpose limbs and hands capable of mobility and manipulation.

### System Enables Collaboration Among Fleets of Robots

February 25, 2014 - <http://www.techbriefs.com/component/content/article/19150> - UNABRIDGED

“Writing a program to control a single autonomous robot navigating an uncertain environment with an erratic communication link is hard. Writing one for multiple robots that may or may not have to work in tandem, depending on the task, is even harder.”



The white robot requested help from the green robot to move a box that is too heavy for one robot to move by itself

“As a consequence, engineers designing control programs for “multi-agent systems” — whether teams of robots or networks of devices with different functions — have generally restricted themselves to special cases, where reliable information about the environment can be assumed or a relatively simple collaborative task can be clearly specified in advance.



“The researchers are testing their system in a simulation of a warehousing application, where teams of robots would be required to retrieve arbitrary objects from indeterminate locations, collaborating as needed to transport heavy loads. The simulations involve small groups of iRobot Create, programmable robots that have the same chassis as the Roomba vacuum cleaner. The robots would be left to execute various macro-actions, and the system would collect data on results. Robots trying to move from point A to point B within the warehouse might end up down a blind alley some percentage of the time, and their communication bandwidth might drop some other percentage of the time; those percentages might vary for robots moving from point B to point C.” ##

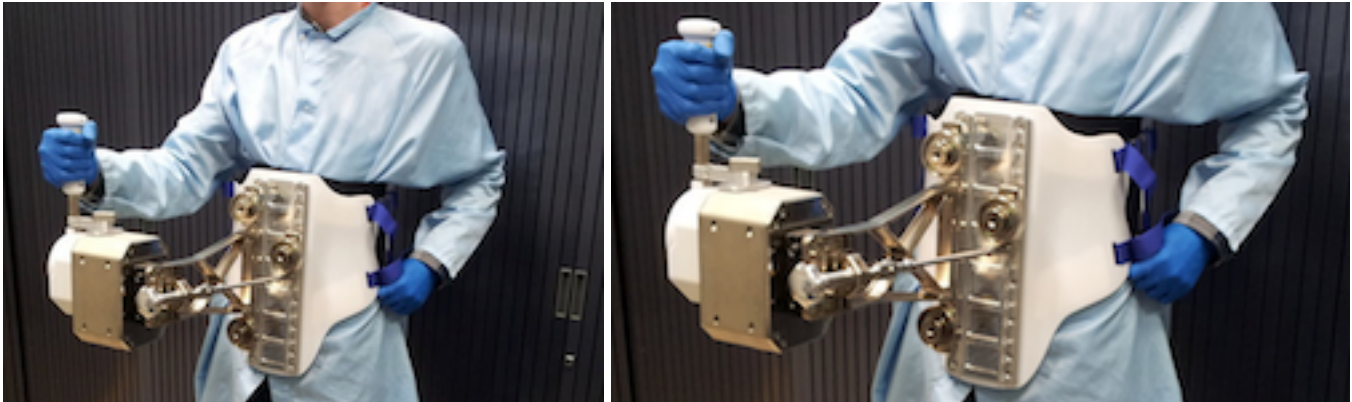
## Astronauts to Test 'Touchy-Feely' Wearable Robot Joystick in Space

<http://www.space.com/25276-joystick-technology-space-station.html>

<http://www.space.com/18952-humans-on-iss-to-control-robots-on-earth-video.html>

March 29, 2014 – This summer, the Space Station crew will test an innovative wearable joystick that may someday allow humans to remotely control robots on other worlds.

[**Editor's note:** effective teleoperation requires the teleoperator to be within a third of a light-second removed, e.g. on a station at LI or L2 around the Moon, or from orbit around Mars.]



<http://i.space.com/images/i/000/038/104/original/body-mounted-astronaut-joystick.jpg?1396043396>

Body-mounted astronaut joystick for the Haptics-1 experiment, developed by the European Space Agency's **Telerobotics and Haptics Laboratory** as part of the multi-agency Meteron (Multi-Purpose End-to-End Robotic Operation Network) initiative, investigating telerobotics for space. The Haptics-1 experiment is being flown to the ISS by ATV-5 in summer 2014. Credit ESA

The European Space Agency will equip the Space Station with a super-sensitive joystick, described by ESA officials as "touchy-feely" to help engineers learn better ways to telerobotically operate a robot on the surface of the Moon or another planet. After each session with the joystick, astronauts will fill out questionnaires on its performance in a study on human motor control in long-term weightlessness.

Astronauts must be close enough for real-time remote control, without any significant signal lag, to benefit from human resourcefulness without the expense and danger of a manned landing.

As every action has an equal and opposite reaction, the joystick apparatus must be attached to a body harness, which in turn is bolted to the inside of the station. If the joystick wasn't secured, moving it would cause the floating astronaut to careen around the room, as the joystick will both resist the astronaut's motions and create forces of its own, simulating the feeling of encountering objects on a moon or planet's surface. By conducting a series of tests, astronauts will help scientists understand how touch feedback feels in microgravity, and what happens to a person's motor control after prolonged periods of weightlessness.

The design challenge was to get the hardware to be both extremely precise and yet incredibly sturdy, The system can produce minute forces most people are not sensitive enough to feel, but hardy enough that a user could kick it and it would still work and respond correctly. ##

## SPACE STATION RESEARCH

### Experimenting with super-critical water that can start fire on the Space Station

<http://www.geekosystem.com/supercritical-water/> Includes VIDEO

February 25, 2014 – If you put it under enough heat and pressure, 273 ATMs at 373°C (703°F) water becomes “supercritical water.” In this ultimate form, it is capable of burning material it comes in contact with, and could prove useful for closed-system human waste management. The experiments will be done using French equipment in the Japanese Experiment Module.

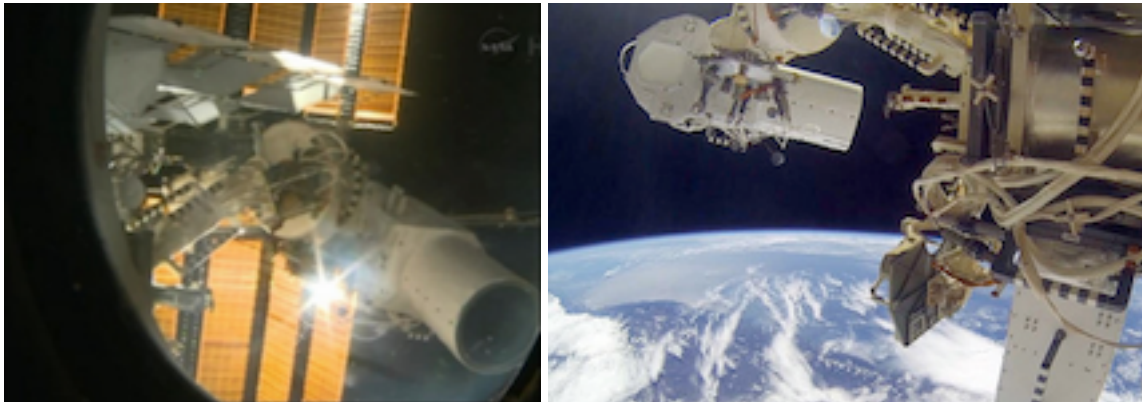
### UrtheCast Cameras Outside Space Station Send First Data Home

<http://www.space.com/24770-urthecast-space-station-cameras-image-test.html>

February 21, 2014 – Two commercial cameras that will keep a constant watch over Earth from outside the International Space Station have beamed their first bits of test data back home.

UrthCast (Vancouver, BC) has not publicly released pictures or videos showing its cameras' view of Earth just yet. But they announced this week that they have successfully downlinked camera data to a ground station in Moscow from both their high-resolution camera and medium-resolution camera. They've even acquired test imagery from the medium-resolution device.

By passing this test, UrthCast is a step closer to providing Internet users and commercial clients with a **stream of near-real time continuous footage of Earth.**



GoPro camera view of UrtheCast's high- (upper left) and medium-resolution (lower right) commercial video cameras mounted on the International Space Station

Further commissioning and calibration of the cameras and the pointing platform for the HRC [high-resolution camera] are necessary before imagery can be acquired from the HRC.

The first "official full color, Ultra HD video" should be released in the second quarter of the year.

The cameras arrived at the station in November as part of Russian cargo delivery and were installed on the hull of the orbiting outpost by Oleg Kotov and Sergey Ryazanskiy on Jan. 27.

The cameras will capture stills and video of the planet from the viewpoint of the station, circling the globe every 90 minutes at an average altitude of 400 km (248 mi). The camera will record 50 km-wide (30 mile) swathes and will be able to identify objects about 6 m (19 ft) across or larger.

The high-resolution camera will be able to resolve targets as small as 1 m (3.3 feet) across. ##

## CUBE SATS – THE BUDGET PATH TO SPACE

### NASA Announces 5th Round of CubeSat Space Mission Candidates

[www.nasa.gov/press/2014/february/nasa-announces-fifth-round-of-cubesat-space-mission-candidates/](http://www.nasa.gov/press/2014/february/nasa-announces-fifth-round-of-cubesat-space-mission-candidates/)

Feb 6, 2014 RELEASE 14-042 NASA has selected 16 small satellites from nine states to fly as auxiliary payloads aboard rockets planned to launch in 2015, 2016 and 2017. The proposed CubeSats come from universities across the country, a primary school, non-profit organizations and NASA field centers.

CubeSats are a class of research spacecraft called nanosatellites. The cube-shaped satellites are about 4 inches on each side, have a volume of about 1 quart and weigh less than 3 pounds.

The selections are from the 5th round of the agency's CubeSat Launch Initiative. These satellites will conduct technology demonstration, educational research or science missions. Those selected are eligible for launch after final negotiations, depending on flight opportunity availability. The organizations

#### Sponsoring Organizations:

- Boston University, Boston, MA
- Brown University, Providence, RI
- Embry-Riddle Aeronautical University, Daytona Beach, FL.
- Johns Hopkins Applied Physics Laboratory, Laurel, MD
- Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, MA
- Marquette University, Milwaukee, WI
- NASA's Ames Research Center, Moffett Field, CA
- NASA's Goddard Space Flight Center, Greenbelt, MD
- New Mexico Institute of Mining and Technology, Socorro, NM
- St. Thomas More Cathedral School, Arlington, VA
- The Aerospace Corporation, El Segundo, CA
- University of California, Los Angeles CA
- University of Florida, Gainesville, FL
- University of Michigan, Ann Arbor, MI
- Utah State University, Logan UT (2 CubeSats)

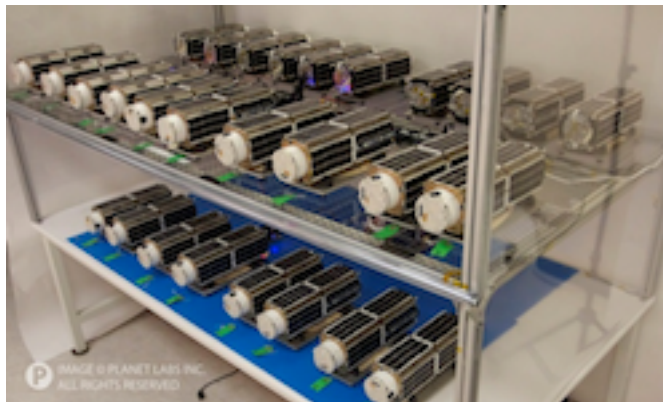
In the previous four rounds, 99 CubeSats from 28 states were selected. This year, four separate launches will carry 17 CubeSats.

**Additional information** on NASA's CubeSat Launch Initiative: [http://go.nasa.gov/CubeSat\\_initiative](http://go.nasa.gov/CubeSat_initiative)

### First 'Cubesats' in Record-Breaking Fleet Launched from Space Station

Feb. 11, 2014 - <http://www.space.com/24651-cubesats-launch-space-station-planet-labs.html>

The world's largest constellation of Earth-imaging satellites HAVE begun taking shape today, when four tiny satellites were ejected from ISS. The four "cubesats," each about the size of a loaf of bread, began circling freely around Earth. Two dozen more will join them over the coming days, to become "Flock 1" satellite "fleet." They are operated by San Francisco-based startup Planet Labs.



The 28 Dove Flock 1 satellites for the U.S. company Planet Labs before delivery to ISS. They form the largest single constellation of Earth-imaging satellites ever to be launched.

Flock 1 will provide frequent, low-cost, high-resolution imagery of Earth that could serve a variety of purposes, **from tracking deforestation and natural disasters to monitoring leaks in oil pipelines.**

The goal is to image "everywhere, very frequently, for everyone," That's going to be quite transformative for a number of countries, and companies.

"Our monitoring capability is always on. We are always taking a picture."

Each of the 28 Flock 1 cubesats measures 30 x 10 x 10 cm (12" x 4" wide by 4" tall). But the tiny spacecraft are quite capable, capturing images with a resolution of 3 to 5 m (10 to 165ft).



Flock 1 will orbit Earth at altitudes ranging from 386 to 644 km (240 to 400 m). They'll gather imagery within 52° N and S of the equator — a swathe that encompasses most of the planet's agricultural regions and populated land. The constellation is flexible, as each satellite's software can be reprogrammed easily from the ground.

We can think about this satellite segment as a **very remote server** with a whole bunch of sensors on board that could be reprogrammed to do other things.

This deployment was not the first time Planet Labs has launched satellites into space. The company launched four prototype Earth-imaging cubesats as part of separate rocket launches last year, two in April and two in November. ##

## SPACE STATIONS

### NASA gets White House backing to extend Space Station by 4 years to 2024

[www.orlandosentinel.com/news/politics/os-space-station-extension-20140107,0,3847257.story](http://www.orlandosentinel.com/news/politics/os-space-station-extension-20140107,0,3847257.story)

Jan 9, 2014 – WASHINGTON — The world's most expensive science project — the \$100 billion-plus NASA plans to announce this week that the Obama Administration has approved extension of the station's operations by four more years until 2024. NASA officials consider the station a critical steppingstone to future exploration.

The problem is that a four-year extension could cost about \$3 billion a year from 2021 to 2024. That must come out of the agency's annual budget, now about \$17 billion – this longer mission could force NASA to make tough financial decisions on other proposed science missions.

The administration's approval does not guarantee that the station, continuously occupied since 2000, will survive past its current end date of 2020. Congress must approve a NASA budget that includes an extension of the station's life. More importantly, the plan also must get the support of whoever wins the US Presidency in 2016. The backing of President Barack Obama now might make it harder for the next administration to renege. This decision should reassure NASA's international partners.

The announcement is also a signal to China, NASA's only space station competitor. China plans to assemble its own space station next decade.

After NASA retired the space shuttle in 2011, the U.S. lost the ability to ferry its own astronauts to the station, and NASA must pay Russia about \$1.7 billion through 2017 for the service. US commercial companies such as Space-X should be ready to ferry US astronauts to the station before 2017. Keeping the station going until 2024 gives these U.S. companies, a chance to fly the NASA missions for several years, helping them compete with rival foreign rocket companies.

NASA officials said they were confident they could keep the outpost aloft for years "through at least 2028," despite occasional problems. "The structural margin of the ISS will be fully adequate to support ISS operations "through at least 2028." Adding four years to the station also would help NASA and its partners recoup their investment in the station, because little science was done aboard the observatory in its early years. "ISS is in its most productive era of utilization for scientific research and technology demonstration." As late as 2008, the crew averaged only three hours of science work a week. Now the six-member team is doing at least 50 hours weekly. Research includes Earth observation, the study of cosmic rays and the effect of spaceflight on astronaut health.

Figuring out how space affects humans will be especially important for an expedition to Mars, a round trip that likely would take years and expose space explorers to a wide variety of dangers, including radiation. The outpost steadily has built a database of health history for space travelers. ##

### Commercial Cygnus Freight Capsule arrives at Space Station

<http://www.nasa.gov/press/2014/january/new-science-nasa-cargo-launches-to-space-station-aboard-orbital-1-mission/>

<http://www.space.com/24254-cygnus-spacecraft-captured-by-space-station-video.html>

[http://en.wikipedia.org/wiki/Cygnus\\_\(spacecraft\)](http://en.wikipedia.org/wiki/Cygnus_(spacecraft))

Jan 12, 2014 – Orbital Sciences Corp.'s Cygnus spacecraft has officially begun contracted cargo flights to the International Space Station. A prior test flight successfully launched on September 18, 2013, 4 months earlier. The launch aboard Orbital's Antares rocket took place from NASA's Wallops Flight Facility in Virginia Thursday, January 9th.



This second flight began the company's first contracted cargo delivery flight to the station through a \$1.9 billion NASA Commercial Resupply Services contract. Orbital will fly at least eight cargo missions to the space station through 2016. Cygnus is berthed at the portion of the space station previously designated a U.S. National Laboratory, managed by CASIS (Center for Advancement of Science in Space) which selects and funds new research to use the national lab's unique microgravity environment to conduct experiments not possible on Earth.

The pressurized Cygnus cargo carrier can accommodate a variety of scientific payloads. The Orbital-1 mission brought 2,780 pounds of supplies to the station, not including the weight of packaging materials. Vital science experiments, crew provisions, spare parts and other hardware were delivered.

More than 10,000 students will be involved with the 23 experiments they designed and which were part of the cargo. In one educational experiment selected by CASIS, students will compare how ants' behavior differs in space and on Earth. Small, relatively inexpensive satellites, CubeSats, will provide a variety of technology demonstrations. They will be launched using the NanoRacks Smallsat Deployment Program from the station's Japanese Experiment Module (JEM) airlock.

One NASA experiment will study the decreased effectiveness of antibiotics during spaceflight. Another will examine how different fuel samples burn in microgravity, which could inform future design for spacecraft materials.

Orbital Sciences is one of two companies that built and tested new cargo spacecraft under NASA's Commercial Orbital Transportation Services (COTS) program. COTS was completed late last year with an Orbital Sciences demonstration mission to the space station. Space Exploration Technologies (SpaceX), the other company that partnered with NASA under COTS, also is providing commercial resupply services for the agency.

In addition to cargo flights, NASA's commercial space partners, Space-X, Boeing, and Sierra Nevada are making progress with new spacecraft toward a launch of astronauts from U.S. soil within the next three years. Space-X and Boeing are designing 7 passenger vehicles reminiscent to the Apollo crew capsules, while Sierra Nevada is making progress with its Dream Chaser 7 passenger shuttle craft. Currently, only the Russian Soyuz is able to fly astronauts to and from the station.

<http://www.space.com/15429-spacex-dragon-space-capsule-manned-infographic.html>

<http://www.space.com/15363-boeing-space-capsule-cst-100-infographic.html>

<http://www.space.com/15366-dream-chaser-private-space-plane-infographic.html>

In addition, for deep space manned missions, Lockheed is working on the 7 passenger Orion.

<http://www.space.com/11777-nasa-deep-space-multi-purpose-crew-vehicle-infographic.html> ##

## Commercial Space Taxi Businesses to get Boost from US 2014 Budget Bill

January 16, 2014 - <http://www.space.com/24310-nasa-budget-commercial-crew-2014.html>

WASHINGTON — NASA's Commercial Crew Program would get up to \$696 million — its highest annual budget yet — under an omnibus spending bill drafted by Congress.

This allocation, however, is still considerably less than the \$821 million sought by the Obama Administration and also comes with a string attached: \$171 million would be held in reserve until NASA completes an independent cost-benefit analysis of the program. If that is not done on time, funding would remain at \$525 million, the same level as in 2013.

The spending bill would extend through 2016 the federal government's launch indemnification program, which shields U.S. commercial launch providers from third-party damage claims that exceed \$500 million. House Democrats had pushed for a one-year extension.

The bill's proposed funding levels for NASA's major spending accounts are:

- **Science:** \$5.2 billion, about \$200 million more than the White House's 2014 request, and \$400 million more than the 2013 budget. Of the proposed 2014 appropriation, 658.2 million is for the [James Webb Space Telescope](#), the agency's biggest science project.
- **Exploration:** \$4.1 billion, about \$100 million more than the request and roughly \$400 million more than in 2013. About \$1.9 billion of the proposed amount is for the Space Launch System heavy-lift rocket and its associated ground systems. The Orion Multi-Purpose crew vehicle, the rocket's companion capsule, would get about \$1.2 billion.
- **Space Operations:** \$3.8 billion, most of which is for the international space station. That is about \$100 million less than the request, and roughly \$100 more than in 2013.

Spending levels in the bill are the result of a December budget compromise that provided some relief from the sequestration of funds for budgets last year as part of the Budget Control Act of 2011. ##

## European Space Agency to help make Dream Chaser a Reality

[www.esa.int/Our\\_Activities/Human\\_Spaceflight/International\\_Space\\_Station/Helping\\_make\\_Dream\\_Chaser\\_a\\_reality](http://www.esa.int/Our_Activities/Human_Spaceflight/International_Space_Station/Helping_make_Dream_Chaser_a_reality)



January 8, 2014 – ESA and American company Sierra Nevada Corporation, have signed an understanding to identify areas of collaboration with European industry for developing hardware and mission concepts for the Dream Chaser orbital transportation system.

Dream Chaser is part of NASA's Commercial Crew Program to transport crew to the International Space Station and back to Earth by 2017. Along with Space-X and its Falcon-9 rocket and Dragon Crew Capsule, Dream Chaser is being developed as a more economical successor to the Space Shuttle, in bringing crew and cargo to the Space Station.

ESA will work to identify how European hardware, software and expertise can be used to further the capabilities of the Dream Chaser orbital crew vehicle. Together they will also study **the possibilities for creating an industrial consortium including European partners to use Dream Chaser for European missions as well as NASA missions.**



To be explored with Sierra Nevada is ESA's International Berthing Docking Mechanism, an advanced docking system designed for use on the International Space Station that would actively capture and seal



the vehicle to the orbiting station. A number of other current and developing technologies and processes will also be evaluated including. On the other hand, of interest to Sierra Nevada is the use of ESA's human factors expertise, simulators and cockpit displays and several other key European offerings which are of interest to SNC.

An initial evaluation and planning phase, will continue through 2014. Both entities foresee further arrangements to continue the partnership towards the potential use of Dream Chaser for European missions. ##

<http://www.space.com/24401-dream-chaser-space-plane-2016-launch.html>

<http://www.space.com/24391-building-the-dream-sierra-nevada-s-dreamchaser-comes-together-video.html>

Jan 24, 2014 – Sierra Nevada has scheduled the first orbital test flight of its private space plane Dream Chaser November 1, 2016, in an unmanned debut flight to prove the spaceship is capable of flying astronauts on round-trip flights into space. It will be launched from Cape Canaveral, Fl. on top of a United Launch Alliance Atlas 5 rocket. The flight will be an autonomous, uncrewed orbital flight that will probably last about one day before landing on the U.S. West Coast

Looking like a miniature version of the now retired NASA space shuttles, Dream Chaser is being built to ferry people and cargo into orbit, but its first flight will be without a crew, to pave the way for manned missions to low-Earth orbit by 2017.

#### **A Fleet of multi-use Dream Chasers, “a space SU”**

Sierra Nevada plans to build a fleet of these vehicles, much like the shuttle fleet, each with different purposes. Some will be **all crew**, some will be **crew and cargo**, some **cargo alone**, some will be **servicing**, At some point there will be **independent science ability** with the vehicle.

Sierra Nevada plans to use the Operations and Checkout facility at NASA's Kennedy Space Center in Florida to prepare the reusable Dream Chaser vehicle before and after its flights. NASA's deep-space Orion capsule is currently being built and tested in the facility as well.

Since the retirement of NASA's space shuttle fleet in 2011, NASA must buy seat on Russian Soyuz space capsules to ferry American and U.S. partner astronauts. Dream Chaser, the Space-X Dragon capsule and Boeing's CST-100 Capsule, and a craft being designed by Blue Origin are expected to take over that service. to the station. None of these will be ready for another two years or so.

<http://www.space.com/23371-dream-chaser-landing-gear-fails-to-deploy-on-test-video.html>

### **Affordable Inflatable Habitats mean more “Buck Rogers’ for less money –**

[www.nasaspaceflight.com/2014/02/affordable-habitats-more-buck-rogers-less-money-bigelow/](http://www.nasaspaceflight.com/2014/02/affordable-habitats-more-buck-rogers-less-money-bigelow/)

[**Note to readers:** the basic technology behind inflatable modules was developed by NASA in its “Transhab” project. When the US Congress refused further funding for the project in 1999, NASA signed a contract with Bigelow Aerospace for further commercial development of the technology.]

Feb 6, 2014 – Robert Bigelow, founder and President of Bigelow Aerospace, believes that cost effective habitats and transportation systems are key to America's space explorations ambitions throughout the solar system. In expansive documentation provided to NASA, Bigelow Aerospace presented a fleet of vehicles that could enable humanity's ambitions.

#### **Inflated Aspirations:**

In the first of two reports recently issued to NASA under the “Gate 1 Report”, Bigelow indicated that he believes that “without cost effective human habitats, America's human space exploration ambitions throughout our solar system are not going to happen. The Las Vegas based company has already put two smaller Nautilus inflatable units in orbit to test their ability to remain inflated and resist puncture from space debris. NASA recently announced that it had ordered a third inflatable to be attached to the space station for further tests where a crew was available. Inflatables allow larger volume units with superior puncture resistance to be launched to space for less money by smaller rockets at less cost using new commercial carriers such as Space-X and Sierra Nevada.

The company will be contracting for a family of transit tugs that it needs for its inflatable habitats, claiming NASA can take advantage of his tugs without having to pay any research and development for them. In the report he writes that cost reduction of rocket technology has never been addressed by NASA and that the commercial sector can help in this respect.

**“Until recently, the commercial sector has been locked out. All the usual cost per pound calculations in use are all based on the wrong production metrics. Under the right leadership, the costs of habitable systems and transportation can be drastically reduced from what has been the usual American experience.”**

Drastically reducing the price for crew transportation is very important for Bigelow. In an interview with NASASpaceflight.com, Mike Gold, Director of D.C. Operations at Bigelow, emphasized the importance Mr. Bigelow holds for affordable crew taxi rides – spacecraft capable of ferrying up to seven passengers or crew up to his future inflatable habitats. Per the reports, Bigelow is proposing the utilization of his BA-330, his Olympus modules and his family of tugs as examples of cost effective habitats and transportation systems that NASA can use to explore the solar system.

#### **The BA 330 Habitat:**

The documentation supplied to NASA provides a description and a price list of the habitats that he can offer the agency. The BA 330 (330 cubic meters of pressurized volume) is a multi-purpose habitat that can have various configurations, to fit the destination. It can sustain a crew of up to six astronauts. Two propulsive thrusters flanking the airlock use monopropellant hydrazine (non-refillable), while the forward propulsion system is regulated gaseous hydrogen/gaseous oxygen system, refillable through the Environmental Control and Life Support (“ECLS”) oxygen generation system. Four arrays extend from the forward airlock, and have two electricity producing photovoltaic arrays and two radiators. BA-330 will use the appropriate NASA Docking Systems (NDS) to support visiting vehicles, in order to attach multiple modules.

The unit should have all the necessities for a long term stay in space for astronauts. It should have “a zero-g toilet with solid and liquid waste collection, semi-private berths for each crew member, exercise equipment, a food storage and preparation station, ample lighting, and a personal hygiene station.” It has a design lifetime of a minimum of twenty years, with systems designed to be double fault tolerant.

#### **The bottom line**

A second “Gate 2 Report” contains a price list for the various versions of the habitats that are offered by Bigelow to NASA, foreign governments and private entities. For commercial customers, the BA 330 would cost \$25M in order to rent a third of the station (i.e., 110 cubic meters) for a period of 60 days. A taxi seat aboard [SpaceX’s Dragonrider](#) to the BA-330 would cost \$26.5M per seat. These prices would include consumables, all on board research equipment, a full time Bigelow Aerospace crew, astronaut training and the ability to take several kilograms of finished research products back to Earth. A pilot and possibly another person responsible for the station keeping would be included. Bigelow stated that until commercial crew is ready, he cannot finalize any contract with potential customers.

#### **New Ideas for Cooperation in Space:**

1. Two BA-330 modules as Low Earth Orbit “Service Stations” for a variety of needs, including trying out hardware that [won’t fit on or inside the ISS](#). “The BA-330s could be used by NASA for outfitting and (for) preparatory exercises for eventual deployment somewhere outside of low Earth orbit.” They could also be used commercially by foreign astronauts in order to keep costs down for NASA.
2. A “long duration vegetable system”, which could produce as much as 20 percent of the food that astronauts consume. “The need for remotely located astronauts to grow and harvest some percentage of the food they consume is also of serious interest to (both) Bigelow Aerospace and NASA.”
3. The fleet consists of the Standard Transit Tug, the Solar Generator Tug, the Docking Node Transporter and the Spacecraft Capture Tug. These tugs could be used to push the various Bigelow Habitats – and other payloads – to destinations in LEO, L2, and beyond. Tugs could be launched independently, prior to rendezvous with other elements in LEO to form a complete transport system. Each of these tugs share propulsion, docking and avionic systems. The Standard Transit Tug would have simple docking adapters at its fore and aft, in order to allow multiple vehicles to be joined together.
4. The Solar Generator Tug could transport large solar panels. The solar arrays could either be deployed in LEO, or once it arrives at its mission destination. Docking adapters on both ends would allow other tugs to be attached.
5. A 5-port Docking Node Transporter Tug would allow visiting spacecraft or other habitats to be docked together. Avionics and communication equipment can be placed inside the docking node.
6. Utilization of medical facilities in space, for emergency surgery.

**Family of Tugs:** (see link above for text)

#### **The BA 330-DS (Deep Space):**

A deep space version of its habitat would be used beyond Low Earth Orbit, for example, at a Lagrange point or in lunar orbit. It would be very similar to its LEO version, but with more radiation

shielding, in the form of water tiles that surround the interior. (The BA 330 (only) provides water tiles for sleeping quarters.) This produces most of the weight difference in the two versions. “The balance of additional mass includes priority attention to radiation hardening of avionics and the weight of additional medical facilities, hardware and spare parts.”

Bigelow is not ready to publicly disclose the prices for renting or for the astronaut taxi ride to a lunar orbiting BA-330-DS, the price for both of these items would be “very reasonable”.



Above: The BA 330 and BA 2100 (Olympus)

### The BA 330-MDS (Modified Deep Space):

A deluxe version of his inflatable habitat, the BA 330-MDS would be designed for use on the Moon’s surface or on Mars. This “expandable module” has appropriate landing propulsion busses. Very similar to the BA 330-DS, the MDS sports enhancements to land on a solid surface. Once landed, they will cover the habitats with regolith, using very simple methods that do not require any kind of machinery. [No further information on these “simple methods” are given in the article. The BA 330-MDS would land on the Moon with the two Docking Node Transporters on each side. Solar arrays on the Docking Node Transporters could provide sufficient power to the unit, until a larger solar field is deployed.



Above: BA 330 Space Station and Lunar Base

### Olympus (BA 2100) [http://en.wikipedia.org/wiki/BA\\_2100](http://en.wikipedia.org/wiki/BA_2100)

The Olympus model as a potential payload for NASA’s the Space Launch System (SLS) now under construction for use in Low Earth Orbit or beyond. It could also be launched on a Space-X Falcon Heavy (should the very expensive non-commercial SLS project be killed, as some space advocates suggest.) This module resembles the BA-330, but on a much larger scale.

It has 2,258 cubic meters of internal volume (nearly 7 times as spacious as the BA 330 and 2.7 times the 837 cubic metres (29,600 cu ft) volume of the whole International Space Station as of April 2013.) And it can accommodate a crew of 24 to 30 astronauts (compared to 6 on the ISS.) Olympus uses a multiple deck concept which allows it to be configured for the needs of multiple programs and has a minimum design lifetime of 20 years.

“Concepts are being developed for hydroponics, medical, science and fitness decks,” as part of its development cycle. The Olympus would not be manufactured in Las Vegas, as it needs to be assembled near a waterway, given its large size. A modified version of the Olympus would be a craft carrier.

### Announcement Coming Soon:

Mr. Gold indicated that having NASA as a customer or partner is very important for Bigelow. He indicated that the recent passage of the FY 2014 Omnibus bill should help NASA being able to announce new programs or initiatives. Bigelow is currently in negotiation with NASA for further activities and is cautiously optimistic that they will be able to make an announcement soon.



## Related Articles

[www.nasaspaceflight.com/2007/01/human-rated-atlas-v-for-bigelow-space-station-details-emerge/](http://www.nasaspaceflight.com/2007/01/human-rated-atlas-v-for-bigelow-space-station-details-emerge/)  
<http://www.nasaspaceflight.com/2006/09/lockheed-and-bigelow-human-rated-eelv-deal/>  
<http://www.nasaspaceflight.com/2012/12/spacex-foot-eelv-door-double-launch-contract-win/>  
<http://www.wired.co.uk/news/archive/2013-01/15/inflatable-iss-extension>

## SPACE TOURISM

### Space Ship 2 reaches highest point yet in tests, could carry passengers this year

[www.space.com/24253-spaceshiptwo-s-3rd-powered-flight-soars-to-new-heights-video.html](http://www.space.com/24253-spaceshiptwo-s-3rd-powered-flight-soars-to-new-heights-video.html)  
<http://www.space.com/24249-commercial-space-travel-blasts-off-2014.html>

At last, the dawn of private manned space travel appears near at hand. Virgin Galactic's suborbital SpaceShipTwo, aced its third supersonic test flight, and company officials say they remain on track to begin commercial service later this year.

SPACE.com surveyed a number of commercial space travel experts, as to what developments we should expect in the field this year — will paying customers will make it into space in 2014?

#### The suborbital sector and government regulations

Virgin Galactic CEO George Whitesides says "We believe this moment will represent a major shift in humanity's relationship with space — the moment when the space environment becomes significantly more accessible to new people, new uses and new science." He underscored the need for loosening governmental red tape to make this vision a reality. "Our major hope is that the export control reform process will conclude in a place that enables the U.S. to continue its global leadership of the suborbital spaceflight sector."



Jan. 10, 2014 SpaceShipTwo space plane rockets through the stratosphere at 22,000 m (71,000 ft) – its highest flight yet, during its 3rd powered test flight.

#### Rocket reality for Space-X also

Spaceport America in New Mexico, is waiting for commercial space travel to become "rocket real," and here is where Virgin Galactic will establish its headquarters and operate its spaceflights from "the world's first purpose-built commercial spaceport."

<http://www.space.com/13801-photos-spaceport-america-commercial-space.html>



A recent development is SpaceX use of Spaceport America to start flying its Falcon 9R reusable rocket — an offshoot of the company's experimental Grasshopper rocket stage that has repeatedly flown from McGregor, Texas. Last year, New Mexico officials announced a three-year agreement to lease land and facilities to SpaceX at Spaceport America for the venture.

Spaceport America's Launch Site Operator License, required by the FAA for the spaceport to host licensed vertical and horizontal launches, has just been renewed by the Federal Aviation Administration Associate Administrator for Commercial Space Transportation (FAA/AST).

A majority of New Mexico Space Authority staff will soon move to the on-site, newly outfitted Spaceport Operations Center. "We're ready to support our tenants, Virgin Galactic and Space-X" ##

**Space Tourism using a Balloon to take Passengers 30,000 m (100,000 ft) up**  
[www.theverge.com/2013/10/22/4866026/paragon-world-view-space-tourism-balloon-trip-announced](http://www.theverge.com/2013/10/22/4866026/paragon-world-view-space-tourism-balloon-trip-announced)  
<http://news.discovery.com/space/private-spaceflight/company-to-balloon-tourists-to-the-edge-of-space-131022.htm> (with must watch video)  
<http://www.cnn.com/2013/10/24/travel/space-balloon-30km/>  
<http://www.gizmag.com/space-tourism-balloon-world-view/29510/>  
<http://www.space.com/16122-space-tourism-balloon-test.html>

A **less expensive** way to get into space is in the design stage, with trips beginning in 2016. A new space tourism venture plans to bring visitors 30 km (19 mi ~ 100,000 ft) into the stratosphere in what is essentially a space-ready air balloon for \$75,000.



Another Design Study: <http://www.designboom.com/technology/bloon-balloon-for-near-space-travel/>

The capsule won't technically be in space — nor high enough to enter orbit and achieve the sensation of true "weightlessness" — but there should be a **wonderful view of the curvature of the Earth, the blue atmosphere around it, and the dark void beyond**. One **won't have to undergo training**, and they'll spend **two hours up at that height, where they'll be free to stand and walk about the cabin**.

The new project comes from World View, a subsidiary of Paragon, which makes equipment for the International Space Station and other space applications. Paragon is also the company behind The Inspiration Mars Foundation project to send a man and woman on a flyby of Mars in 2018!

A helium-filled, high altitude balloon will carry the capsule to its maximum height. Few details are available, as World View has to go through plenty of regulatory and testing hurdles before becoming a reality, but the project is not so different from Felix Baumgartner's trip in the Red Bull Stratos last year, which took the skydiver to a height of 39 km (128,000 ft.)

The "World View passenger module" isn't a rocket — but a pressurized, 4-ton capsule or gondola with **large windows**, and **spacious** enough to hold up to eight passengers. But a trip can be reserved for the private experience of two persons, for example, at a proportionately higher ticket price for each.

#### **Morning or Night Terminator passages, or all daylight or all night flights**

The sky will be dark blue, almost black at that height, even though it may be daylight on the surface below. Passengers can choose the time of day, If they are over the night terminator (which moves westward about 1,000 miles an hour) they will see part of the world in daylight, and city lights in the portion where the sun has already set or begin in daylight and watch night set (over the two hours) or vice versa watching the morning terminator pass below. 21

The time at maximum altitude – two hours – will be significantly longer than that afforded by SpaceShipTwo or Lynx.

It gets better – To get back to Earth, the passengers can choose from three minutes long options,

- Slowest descent at 3/8th G – 2 minutes of Mars level gravity,
- Medium descent 1/6th G – Moon level gravity,
- Fastest free fall zero-G – all controlled by the amount of helium allowed to remain in the balloon above.
- You can **choose what part of Earth your flight will be over!**

Alternative designs: <http://www.cutedecision.com/wp-content/uploads/2011/08/bloon-5.jpg> left



Left: <http://www.cutedecision.com/wp-content/uploads/2011/08/bloon-5.jpg>

Right: <http://www.designboom.com/technology/bloon-balloon-for-near-space-travel/>

**Editor:** If I had the money, I would choose a “Bloon” flight over SpaceShipTwo or Lynx flight, “hands down” with no hesitation. On the rockets, you may go a little higher and the sky might be a little darker, but you won’t be up long enough to experience the terminator transitions, or to experience different G levels, that of Mars or the Moon. If this project is realized, it could well be the most popular, by far. ##

## MISSION TO PLANET EARTH

### Five NASA Earth Science Missions for 2014

<http://www.space.com/24408-nasa-earth-right-now-mission-photos.html>

<http://www.space.com/24433-nasa-earth-observation-missions-2014.htm>

Jan 27, 2014 NASA will launch five Earth-science missions in 2014, starting with the Feb. 27 liftoff of the **Global Precipitation Measurement (GPM) Core Observatory** from Japan's Tanegashima Space Center.

[See Article immediately below]

Next is **ISS-RapidScat**, to launch to ISS June 6, aboard SpaceX's unmanned Dragon cargo capsule. ISS-RapidScat will gather **data about ocean winds around the ground**, aiding climate research and improving the tracking of storms and hurricanes. In September, Dragon will carry another NASA instrument to ISS, the **Cloud-Aerosol Transport System**, to **measure small particles in the atmosphere**, which can affect human health and influence global climate, agency officials said.

The other two NASA Earth-observation missions. In July, the **Orbiting Carbon Observatory 2**, a replacement for a satellite doomed by a launch-vehicle failure in 2009. OCO-2 will make **detailed measurements of carbon dioxide**, improving researchers' understanding of this greenhouse gas and how it cycles through land, air and sea. NASA also aims to launch its **Soil Moisture Active Passive mission** in November. SMAP is designed to map the planet's **soil moisture** helping scientists better predict agricultural productivity, weather and climate, agency. ##



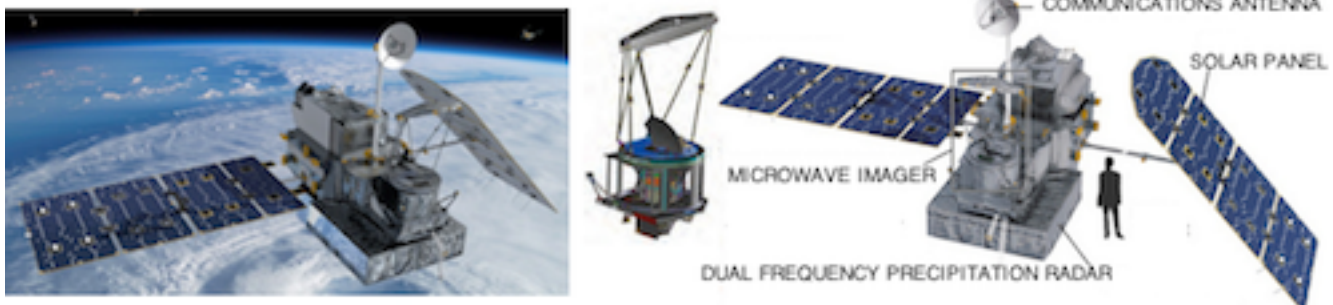
## Japan Launches Next-Generation NASA Satellite to Track Rain & Snow

February 27, 2014 – [www.space.com/24838-japan-launches-advanced-rain-snow-satellite.html](http://www.space.com/24838-japan-launches-advanced-rain-snow-satellite.html)  
<http://www.space.com/24793-rain-and-snowfall-observation-in-real-time-video.html>  
<http://www.space.com/24842-nasa-gpm-satellite-launch-photos-japan-rocket.html>  
[www.space.com/24836-global-precipitation-measurement-satellite-explained-infographic.html](http://www.space.com/24836-global-precipitation-measurement-satellite-explained-infographic.html)

The **Global Precipitation Measurement (GPM) Core Observatory**, a joint effort between NASA and the Japan Aerospace Exploration Agency (JAXA), blasted off aboard an H-2A rocket from Japan's Tanegashima, its mission to observe rainfall and snowfall around the globe in unprecedented detail. GPM will deliver near real-time observations of precipitation every three hours all over the world, greatly improving our understanding of climate change and the global water cycle.

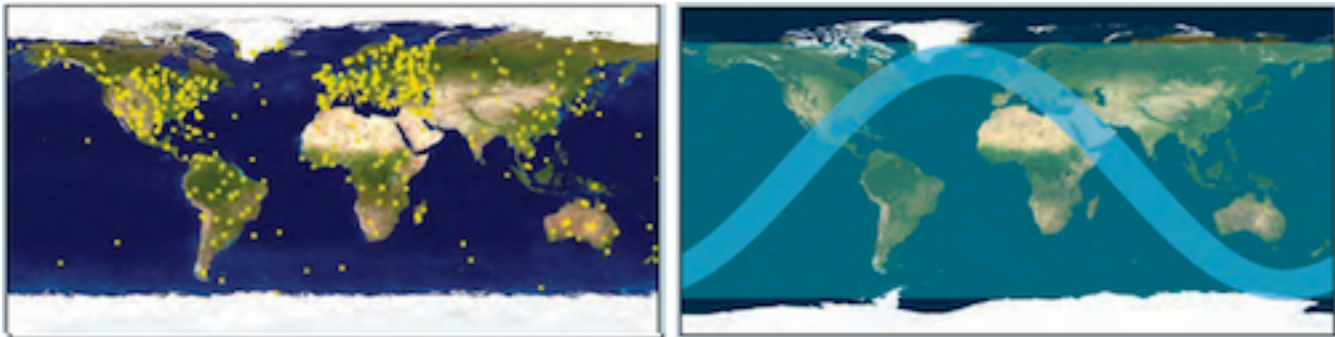
Orbiting Earth at an altitude of 407 km (253 mi), about as high up as the International Space Station, circling the planet once every 93 minutes, about 16 times a day, the 3,850 kg (8,500 lb) satellite will give us the most accurate and advanced precipitation measurements to date.

The satellite uses two instruments — the GPM Microwave Imager (GMI) and the Dual-frequency Precipitation Radar (DPR) — to study rainfall and snowfall from the Arctic Circle in the north to the Antarctic Circle in the south, providing great coverage of clouds and storm systems.

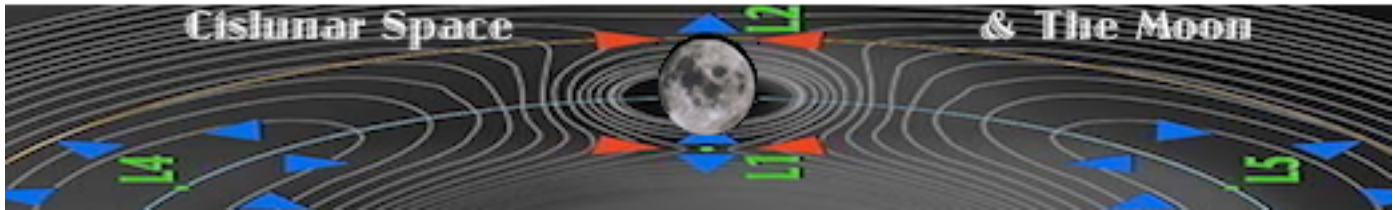


The Global Precipitation Measurement (GPM) Core Observatory

"The GMI will sense the total precipitation within all cloud layers, including, for the first time, light rain and snowfall. The DPR will make detailed 3-D measurements of precipitation structures and rates, as well as particle drop size."



The satellite will also anchor an international network of weather and climate satellites, some of which are already in orbit. It was designed to last for a minimum of three years, but might continue to gather data for much longer than that. ##



## CISLUNAR SPACE

## THE MOON

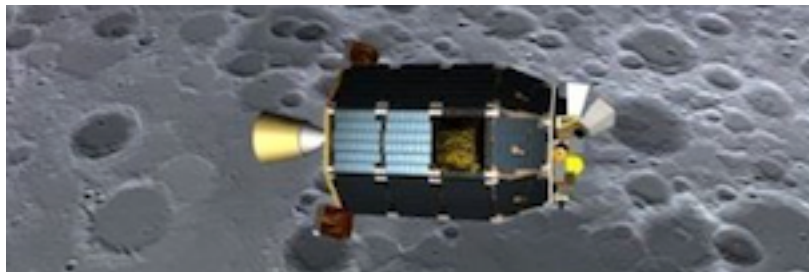
We insist on capitalizing "Moon" when it refers to Earth's satellite. Read why:

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

## NASA LADEE Mission extended 4 weeks to April 21st

[http://www.space-travel.com/reports/NASA\\_Extends\\_Moon\\_Exploring\\_Satellite\\_Mission\\_999.html](http://www.space-travel.com/reports/NASA_Extends_Moon_Exploring_Satellite_Mission_999.html)

Feb 06, 2014 – The Lunar Atmosphere and Dust Environment Explorer (LADEE) will get the opportunity to gather an additional full lunar cycle worth of very low-altitude data to help unravel the mysteries of the lunar atmosphere. This opportunity comes as a result of high launch vehicle performance and extremely accurate orbit capture burns, so the orbiter had significant propellant remaining. to enable significant extra science. LADEE began its orbital mission on October 6, 2013.



The craft orbits around the moon's equator at an altitude of 12–60 km (8–37 mi) above the surface; a unique position that allows tLADEE to pass from lunar day to lunar night and then from night to day, frequently, about every two hours. This vantage provides data about the full scope of changes and processes occurring within the Moon's tenuous atmosphere as the terminator, the line between evening daylight and nighttime and then the terminator between nighttime and advancing daybreak.

"The science team has already established a baseline of data for the tenuous lunar atmosphere, or exosphere, and dust impacts. During this NASA plans to fly LADEE at only a few kilometers above the lunar surface, much lower than it has been, to better sample the dusk cloud that advances with each terminator."

"Using a set of three instruments, scientists are able to measure the chemical composition of the atmosphere, collect and analyze samples of lunar dust particles in the atmosphere and hope to address a long-standing question: Was lunar dust, electrically charged by sunlight, responsible for the pre-sunrise glow above the lunar horizon detected during several Apollo missions?"

The **Neutral Mass Spectrometer** points in different directions to look for atoms and molecules in the lunar atmosphere from various sources, and has measured three noble gases: helium, neon, and argon-40; three elements do not combine with others but have important uses nonetheless.

LADEE's **Ultraviolet-Visible Spectrometer** peers over the lunar horizon to look for the glow of atoms, molecules and dust in the lunar atmosphere and has made measurements of atmospheric sodium and potassium at lunar sunset, sunrise and noon.

The **Lunar Dust Experiment (LDEX)** recorded dust impacts as soon as its cover opened and has measured the dust tossed up by a fairly steady "rain" of meteoroids on the lunar surface. LDEX occasionally sees an increase in dust impacts due to meteoroid showers, such as the Geminids, and "dust bursts" that may be due to LADEE flying through plumes kicked up from nearby meteoroid impacts.

Detailed information about the structure and composition of the thin lunar atmosphere and whether dust is being lofted into the lunar sky will help researchers understand other bodies in the solar system, such as large asteroids, Mercury and the moons of outer planets.

But while this knowledge will be welcome, this information will be of great practical importance in helping us design and plan lunar outposts and spaceport so that the passing terminator and its dust cloud does not cause problems. This information will also tell us whether we have to shutter telescopes on the Moon so that dust from the passing dawn and nightfall terminators does not damage the optics. ##

<http://www.space.com/24713-nasa-moon-probe-ladee-first-images.html>

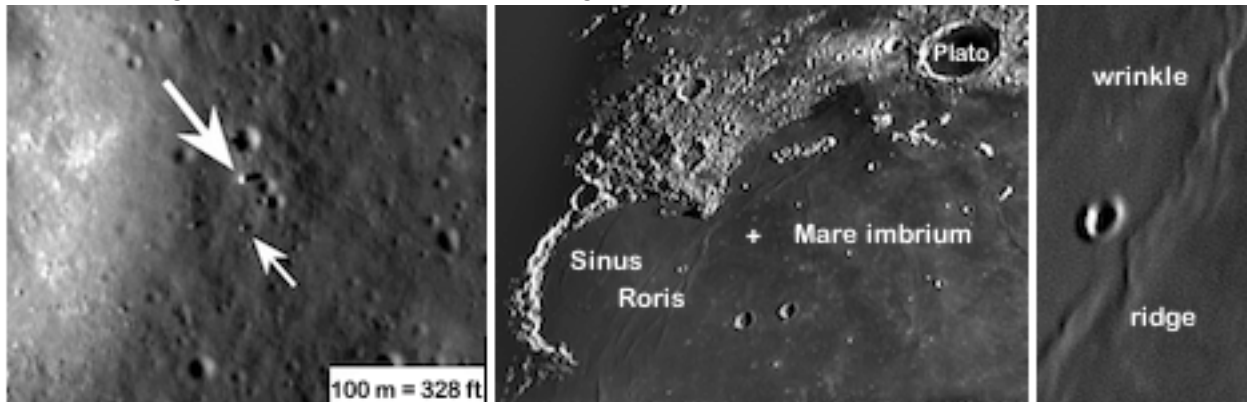
## Chang'e 3 Lander and Rover Seen From Above by LRO

[http://www.space-travel.com/reports/Chang\\_e\\_3\\_Lander\\_and\\_Rover\\_From\\_Above\\_999.html](http://www.space-travel.com/reports/Chang_e_3_Lander_and_Rover_From_Above_999.html)

Dec 31, 2013 – Chang'e 3 landed on Mare Imbrium (Sea of Rains) just east of a 450 m (1,500 ft) diameter impact crater on 14 December, 2013. Soon after landing, the small rover “Yutu” (“Jade Rabbit”) was deployed and took its first drive on the moondust. At that time LRO (NASA’s Lunar Reconnaissance Orbiter) was far from the landing site, unable to take photos of the landing event itself.

Ten days later on 24 December, LRO approached the landing site, and LRO was able to acquire a series of six LROC Narrow Angle Camera (NAC) image pairs during the next 36 hours (19 orbits). The highest resolution image was possible when LRO was nearly overhead on 25 December 03:52:49 UT. At this time LRO was at an altitude of ~150 km above the site; the pixel size was 150 cm.

Yutu is only about 150 cm wide (5'). Its solar panels are very effective at reflecting light so they show up as two bright pixels, and the Sun is setting thus both rover and lander cast distinct shadows.



“Since the rover is close to the size of a pixel, how can we be sure we are seeing the rover and not a comparably sized boulder? Fortunately, the NAC acquired a “before” image (M1127248516R) of the landing site, with nearly identical lighting, on 30 June 2013. By comparing the before and after landing site images, the LROC team confirmed the position of the lander and rover, and derived accurate map coordinates for the lander (44.1214N, 340.4884E, -2640 meters elevation).”

The lander set down about 60 m (200') east of the rim of a 450 m (1,500') wide crater, 40 m (130') deep on a thick deposit of volcanic materials. A large “wrinkle ridge” ~100 km (62 mi) long, 10 km (6 mi) wide cuts across the area, formed as tectonic stress caused the volcanic layers to buckle and break along faults. These features are common on the Moon, Mercury and Mars.

The actual landing site is east and a bit south of the intended site in Sinus Roris. This should not affect the mission. It might be serendipitous, giving us knowledge that we might not have gained if the landing had been on target. Stay tuned! ##



This image is a five-position 360° panorama of the Chang'e-3, Yutu Rover landing site created by Ken Kremer and Marco Di Lorenzo, stitched from individual pictures. The initial panoramic was then enhanced to improve contrast, lighting and uniformity, which revealed more detail. The actual image is ten times as large: – <http://www.space.com/24825-china-moon-rover-photos-stunning-panoramas.html>

About LRO – <http://lro.gsfc.nasa.gov> – [http://www.nasa.gov/mission\\_pages/LRO/main/](http://www.nasa.gov/mission_pages/LRO/main/)  
[http://en.wikipedia.org/wiki/Lunar\\_Reconnaissance\\_Orbiter](http://en.wikipedia.org/wiki/Lunar_Reconnaissance_Orbiter)

About Mare Imbrium – [http://en.wikipedia.org/wiki/Mare\\_Imbrium](http://en.wikipedia.org/wiki/Mare_Imbrium)



## New Data from Chang'e-3 Lander and Rover

<http://www.planetary.org/blogs/emily-lakdawalla/2014/01141430-updates-on-change-3.html>

[http://www.space-travel.com/reports/Moon\\_rover\\_lander\\_wake\\_after\\_lunar\\_night\\_999.html](http://www.space-travel.com/reports/Moon_rover_lander_wake_after_lunar_night_999.html)

Jan 16, 2014 – The Yutu rover has sent us ultraviolet view of the Earth, and an extreme-ultraviolet view, which studies the plasma environment around the home planet. The two images, which are not very detailed, show that the instrument is working properly. The images are at different depths, representing the radar instrument's two different frequencies. There are also first, preliminary images and graphs with the results of the rover's measurements of the composition of the lunar soil.



According to news reports from China, the Yutu rover woke up from its two-week nap at 5:09 Beijing time on January 11 (21:09 on January 10, UTC), successfully establishing communication with Earth. That means its folding solar panel and the camera mast have both re-deployed following their stowage in preparation for hibernation.

The lander woke up autonomously at 8:21 Beijing time / 00:21 UTC on January 12, and is also "in normal condition." A state television report posted today said that Yutu completed its first "exploration of the lunar soil" but didn't provide much in the way of specifics about what that meant. What's next for the mission? Science for the lander, and driving for the rover. The rover can drive upwards of 200 meters per hour, pausing every 7 to 10 meters for imaging for autonomous hazard avoidance.

### Lander instruments

- Three color "topography cameras" for terrain imaging
- Descent camera (1280x1024 pixels)
- Near-ultraviolet telescope (wavelength range 245 to 340 nanometers) for stellar observations down to 13th magnitude
- Extreme ultraviolet camera for observing Earth's plasmasphere

### Rover instruments

- Two color panoramic cameras for stereo imaging
- Two mast-mounted navcams and two forward-facing hazcams
- Ground-penetrating radar (to depths of 30-100 meters)
- Alpha particle X-ray spectrometer
- Visible / near-infrared imaging spectrometer

[http://www.space-travel.com/reports/Change\\_3\\_probe\\_sets\\_out\\_on\\_new\\_missions\\_999.html](http://www.space-travel.com/reports/Change_3_probe_sets_out_on_new_missions_999.html)

[http://www.space-travel.com/reports/Chinas\\_lunar\\_probe\\_observes\\_stars\\_explores\\_moon\\_999.html](http://www.space-travel.com/reports/Chinas_lunar_probe_observes_stars_explores_moon_999.html)

<http://www.space-travel.com/reports/>

[Change\\_3\\_satellite\\_payload\\_APXS\\_obtained\\_its\\_first\\_spectrum\\_of\\_lunar\\_regolith\\_999.html](http://www.space-travel.com/reports/Change_3_satellite_payload_APXS_obtained_its_first_spectrum_of_lunar_regolith_999.html)

## Moon plays trick on Jade Rabbit

[http://www.space-travel.com/reports/Is\\_Yutu\\_Stuck\\_999.html](http://www.space-travel.com/reports/Is_Yutu_Stuck_999.html)

[http://news.xinhuanet.com/english/china/2014-01/25/c\\_133073239.htm](http://news.xinhuanet.com/english/china/2014-01/25/c_133073239.htm)

<http://www.space.com/24441-china-s-moon-rover-already-in-trouble-video.html>

<http://www.space.com/24688-china-moon-rover-survives.html>

[http://www.spacedaily.com/reports/Moon\\_plays\\_trick\\_on\\_Jade\\_Rabbit\\_999.html](http://www.spacedaily.com/reports/Moon_plays_trick_on_Jade_Rabbit_999.html)

Feb 4, 2014 Troubles plaguing China's Yutu (Jade Rabbit) Moon rover are yet another reminder to mankind of how difficult lunar exploration is. In 2016, Russia is planning to launch Luna-25, a cutting-edge lunar lander consisting of five modules.

The "mechanical control abnormalities" experienced by Jade Rabbit owe to a "complicated lunar surface environment", the Chinese media reported. Bloggers were more precise: solar panels failed to fold back properly as the rover was preparing to shut down for its second lunar dormancy period. Tiny particles of rock that got into the mechanism or a computer fault, anything could be to blame: high radiation levels, low gravity and sharp temperature fluctuations on the Moon.

"It would be more effective if an apparatus uses all the energy it generates to keep itself warm. Our apparatus will be wrapped in a special blanket of multilayer film and will retain minimum operating capacity throughout the dormancy period.

Soviet lunar rovers also periodically "fell asleep". Scientists soon became aware of a treacherous nature of lunar dust. Electrified dust particles stuck to solar panels, reducing their efficiency and preventing batteries from being fully charged.

[http://www.spacedaily.com/reports/Whats\\_up\\_Yutu\\_999.html](http://www.spacedaily.com/reports/Whats_up_Yutu_999.html)

[http://www.spacedaily.com/reports/Yutu\\_Awakes\\_999.html](http://www.spacedaily.com/reports/Yutu_Awakes_999.html)

[http://www.spacedaily.com/reports/Waiting\\_for\\_Yutu\\_999.html](http://www.spacedaily.com/reports/Waiting_for_Yutu_999.html)

<http://www.space.com/24688-china-moon-rover-survives.html>

[www.space-travel.com/reports/China\\_Focus\\_Uneasy\\_rest\\_begins\\_for\\_Chinas\\_troubled\\_Yutu\\_rover\\_999.html](http://www.space-travel.com/reports/China_Focus_Uneasy_rest_begins_for_Chinas_troubled_Yutu_rover_999.html)

## Is Yutu (China's Moon Rover) Stuck?

February 24, 2014 – [http://www.space-travel.com/reports/Is\\_Yutu\\_Stuck\\_999.html](http://www.space-travel.com/reports/Is_Yutu_Stuck_999.html)

Finally, China has released some tangible information on the state of its Yutu Moon rover through official state media channels. The results are encouraging, given the fact that we feared Yutu was in a totally useless state. According to Xinhua, China's state media agency, Yutu's "radar, panorama camera and infrared imaging equipment are functioning normally". This holds the promise of more scientific data being returned from the rover. It also shows that the sub-systems required to operate these payloads, such as power and telemetry systems, also work.

But Yutu may have other problems. There is a mechanical control problem with the rover's mobility. It seems that Yutu either cannot drive well or cannot drive at all. Some originally expected that Yutu would be able to move but not operate some of its more fragile scientific instruments. In reality, it seems that the opposite is true. The original word was that a solar panel failed to fold inwards to protect the rover during the lunar night, suggesting a mechanical problem with its hinge mechanism.

Have there also been mechanical problems with the wheels? The wheels are in direct contact with the lunar surface, exposed to highly abrasive and electrically charged lunar dust. It is possible that lunar dust has jammed some of the wheels or associated mechanisms.

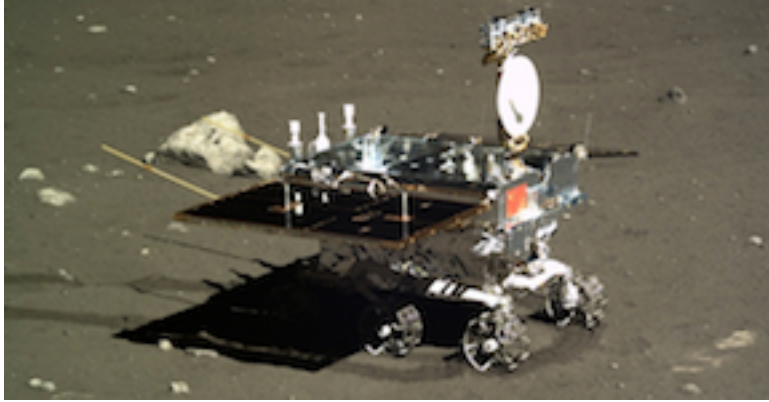
A stationary rover can still take images, and the changing angle of the sun will provide differences in the appearance of the terrain. The infrared camera will be especially useful for such observations, watching how rocks deal with heat transfer. Thus we might have a pair of ground stations and to the extent that their instruments are duplicated, that would provide a valuable check on data.

While it is disappointing to watch Yutu's problems, but we cannot ignore the benefits. China is gaining some solid engineering data on how its hardware performs under actual conditions. Some things work better than others. This was one of the main goals of the mission, and in that regard, the mission has been a success. ##

## China's Moon rover Yutu is awake, still taking data, but still immobile

<http://www.nature.com/news/china-s-moon-rover-awake-but-immobile-1.14906>

March 19, 2014 – China's Moon rover Yutu, or 'Jade Rabbit', has stopped "hopping," but its ears are still twitching — and communicating with Earth. Last week Yutu and its companion spacecraft, the Chang'e 3 Moon lander, awoke from a period of dormancy after the frigid, two-week lunar night ("nightspan") — the third awakening since landing on 14 December. Both probes continue to gather data and send it back to Earth. But Yutu may never move more than the 100–110 metres (330–360 ft) it has already travelled from its landing site — in the Mare Imbrium. Mission officials had hoped that Yutu would travel to the rim of a nearby crater and explore it, but a mechanical failure in Yutu's drive system has stilled the rover since late January.



The rover has used its ground-penetrating radar to probe the structure of the lunar soil more than 100 metres deep. This data are still being processed, but Le Qiao, a planetary scientist at the China University of Geosciences in Wuhan, is anxious to see whether the results confirm **the thickness of basaltic rocks at the landing site**. Using satellite images of craters that expose the underlying layer, Qiao's team estimates that the basaltic rocks are 41–46 metres thick at the landing site.

Early results from the rover's alpha-particle X-ray spectrometer also hint at the chemical composition of the landing site: magnesium, aluminium, silicon, potassium and calcium.

But as Yutu can no longer gather data from different areas, much of the advantage of having a rover is lost.

Alexander Basilevsky, a lunar geologist at the Vernadsky Institute of Geochemistry and Analytical Chemistry in Moscow, hopes to compare the geology of Yutu's landing site to a site about 500 kilometres away, where the Soviet Lunokhod-1 rover travelled in 1970. Comparing the two could show how widespread different rock types are in the region.

Chang'e 4, a mission similar to Chang'e 3, will launch to a different part of the Moon next year.

## Record-Breaking Meteorite Crash on Moon Sparks Brightest Lunar Explosion Ever

[www.space.com/24789-moon-meteorite-impact-brightest-lunar-explosion.html](http://www.space.com/24789-moon-meteorite-impact-brightest-lunar-explosion.html)

<http://www.space.com/24786-bam-38-000-mph-space-rock-slams-into-moon-video.html>

[www.space.com/24788-moon-blast-boulder-sized-meteor-creates-131-foot-wide-crater-video.html](http://www.space.com/24788-moon-blast-boulder-sized-meteor-creates-131-foot-wide-crater-video.html)

February 24, 2014 – The high-speed impact of a space rock on the surface of the Moon on September 11, 2013 created the brightest lunar explosion ever seen and recorded.

Video footage of the meteorite strike unveiled February 24, 2014, shows a long flash that was almost as bright as the North Star Polaris. That means the boulder-sized meteorite's crash could have been visible to anyone on Earth who happened to be staring up at the Moon at the time.

The meteorite hit at high speed, 61,000 km/h (37,000 mph) gouging out a new crater roughly 40 m (131 ft) wide in the ancient lava-filled lunar basin known as Mare Nubium. Scientists think the impacting boulder had a mass of 400 kg (880 lbs) and measured between 0.6 and 1.4 m (2 and 4.5 ft) in diameter.

A rock this size coming our way, would have burned up in Earth's atmosphere, possibly creating some spectacular fireball meteors, but posing no threat to people on the ground.

Back to the Moon: the energy released by the September 2013 impact was comparable to an explosion of roughly 15 tons of TNT. It was at least three times more powerful than the largest previously observed impact spotted by NASA scientists on March 17, 2013. During that crash, a space rock hit at an estimated 90,000 km/h (56,000 mph), carving a new crater 65 feet (20 meters) wide.

Typically, the flashes from these impacts last only a fraction of a second, but this bright spot glowed for eight seconds, making it the longest observed impact flash. Since 2005, NASA's lunar impact-monitoring program has observed more than 300 meteorite strikes on the lunar surface.

"Our telescopes will continue observing the Moon. In this way we expect to identify clusters of rocks that could give rise to common impacts on both bodies. We want to find out where the impacting bodies come from." ##



## Scientists Petition U.S. Congress for Return to the Moon

Dec. 23, 2013 – <http://www.space.com/24068-destination-moon-petition-congress.html>

[Summary of an article by Leonard David]

[See the article “**What A Difference A Year Makes: The LEAG Fall 2013 Meeting**”

By David Dunlop, in TTSIQ#6 January 2014, pp. 102–5]

China’s successful landing of Chang’e 3 and its rover “Yutu” has helped spur a political crusade in the United States to more aggressively explore and utilize the Moon. This effort is led by the **Lunar Exploration Analysis Group (LEAG)**, a group chartered by NASA Headquarters to assist in planning the scientific exploration of the Moon.

LEAG is organizing a letter writing campaign to Congress to underscore the importance of the Moon. The LEAG strategy under the banner “Destination Moon” has a straightforward goal: “**Use the Moon to create a sustained human space-faring capability, advancing exploration of the Solar System.**” A flyer with this title with a cover letter, has been sent to all members of the U.S. House of Representatives and Senate committees that have influence on NASA funding, and to all the lawmakers of the LEAG executive committee members.

Now that Chang’e 3 has landed, LEAG want to champion the Moon in the U.S. Clive Neal, a leading lunar scientist at the University of Notre Dame’s Department of Civil and Environmental Engineering and Earth Sciences told SPACE.com. He is a member of LEAG’s executive committee.

The argument stresses the value of exploring the Moon, from opening the gateway to the solar system, pioneering development of new technologies, as well as advancing economic expansion, enabling new scientific discoveries and promoting international partnerships.

**“The Moon is the most accessible destination  
for realizing commercial, exploration, and scientific objectives beyond low Earth orbit.”**

Destination Moon supporters also site these key points:

- Lunar resources can be used for fuel and life support for operations in Earth–Moon space as well as for voyages to Mars and beyond.
- America can still lead the world beyond low Earth orbit by forging collaborations to make the frontier of space accessible to all.
- Scientific investigations on the surface of the Moon uniquely support studies of early Solar System events that have been erased from Earth’s record.

**Additional points** by Stephen Mackwell, director of the Lunar and Planetary Institute in Houston

- Lunar “The brief Apollo missions were terminated before we could start investigating the requirements for longer term missions away from Earth.”
- “Before we set off to distant destinations, like Mars, it makes sense to use our nearest near–Earth object — the Moon — as a test–bed to see how humans will cope with longer duration periods distant from Earth, including on the surface of another planetary body, and how effectively we can make use of in–situ resources to sustain our presence elsewhere.”

### **Political boost**

Independent of the LEAG letter writing campaign, Rep. Frank Wolf (R–VA) asks President Obama to hold a White House conference early in 2014 of “the best minds from around the country and among our international partners” to develop a mission concept for a U.S.–led return to the Moon within the next 10 years. Wolf makes the point that the Obama administration’s “recalcitrance in leading a lunar mission is creating a crisis of confidence in the U.S. space program, both at home but also among our partners, including Europe, Canada, Japan and Russia.”

### **Enter Chang’e 3**

Mike Gold (Bigelow Aerospace) makes the point: “Chinese leadership clearly understands the importance and potential benefits of lunar activities and we here at home ignore the Moon at our own peril.

It’s not a matter of if the Moon will be utilized for commercial activities, it’s a matter of when and who will enjoy those benefits. “The Moon represents an unparalleled commercial opportunity, and Congress should be looking for ways to expand commercial space operations beyond low–Earth orbit.” ##  
**Apollo Missions in Pictures: [www.space.com/12771-nasa-apollo-missions-photo-countdown.html](http://www.space.com/12771-nasa-apollo-missions-photo-countdown.html)**

## NASA Releases First Interactive Mosaic of Lunar North Pole

[www.nasa.gov/press/2014/march/nasa-releases-first-interactive-mosaic-of-lunar-north-pole/](http://www.nasa.gov/press/2014/march/nasa-releases-first-interactive-mosaic-of-lunar-north-pole/)  
<http://lroc.sese.asu.edu/news/index.php?/archives/874-681-Gigapixels!.html> – 1819X1819 pixel image  
[http://lroc.sese.asu.edu/news/uploads/GigapanScale\\_small\\_flat.png](http://lroc.sese.asu.edu/news/uploads/GigapanScale_small_flat.png)

March 18, 2014 – Scientists, using cameras aboard NASA's Lunar Reconnaissance Orbiter (LRO), have created the largest high resolution mosaic of the Moon's north polar region. The 2 m/pixel (6.5 ft) images cover an area equal to more than one-quarter of the United States.

Web viewers can zoom in and out, and pan around an area. Constructed from 10,581 pictures, the mosaic provides enough detail to see textures and subtle shading of the lunar terrain. Consistent lighting throughout the images makes it easy to compare different regions.

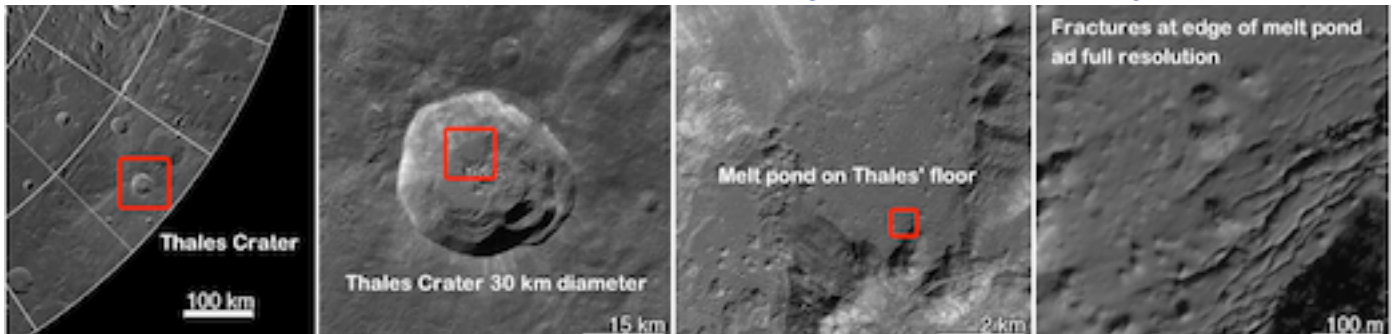
The images making up the mosaic were taken by the two LRO Narrow Angle Cameras, part of the instrument suite known as the Lunar Reconnaissance Orbiter Camera (LROC). The cameras can record a tremendous dynamic range of lit and shadowed areas.

Creation of this giant mosaic (931,070 pixels square – nearly 867 billion pixels total) took four years and has produced a nearly uniform map to unravel key science questions and find the best landing spots for future exploration. A complete printout at 300 dots per inch – considered crisp resolution for printed publications – would require a square sheet of paper wider than a professional U.S. football field and almost as long. If the complete mosaic were processed as a single file, it would require approximately 3.3 terabytes of storage space. Instead, the processed mosaic was divided into millions of small, compressed files, making it manageable for users to view and navigate around the image using a web browser.

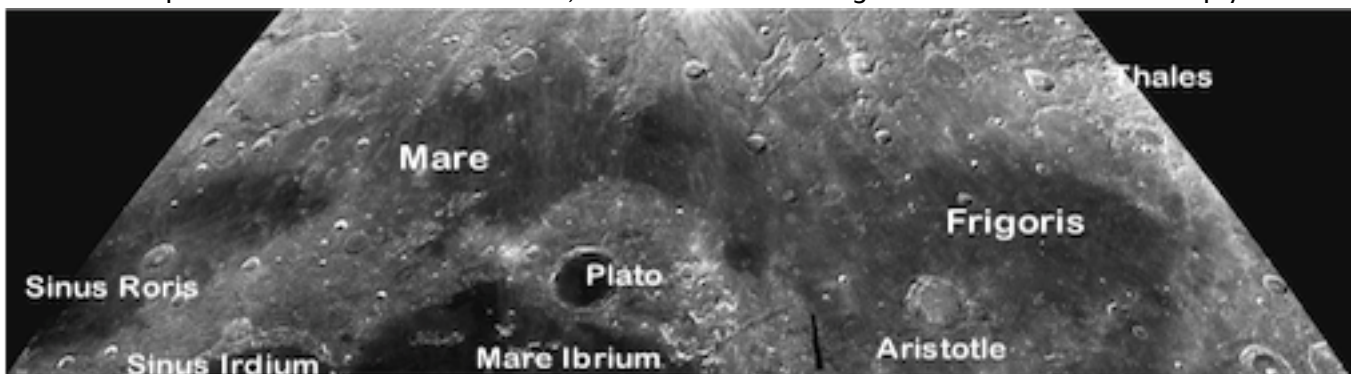
LRO entered lunar orbit in June 2009 equipped with seven instrument suites to map the surface, probe the radiation environment, investigate water and key mineral resources, and gather geological clues about the Moon's evolution. ##

## Thales Crater 30°S of North Pole has Ice deposits

March 18, 2014 – [http://en.wikipedia.org/wiki/Thales\\_\(crater\)](http://en.wikipedia.org/wiki/Thales_(crater))  
[http://lroc.sese.asu.edu/news/uploads/GigapanScale\\_small\\_flat.png](http://lroc.sese.asu.edu/news/uploads/GigapanScale_small_flat.png)



**Not surprising:** This crater has been noted for transient lunar phenomena. In 1892, E.E> Barnard observed a pale haze fill the crater interior, while the surroundings remained clear and sharply visible.



### Editor's Comments

It has been known since the Lunar Prospector mission in 1998 that craters with ice are to be found as far south (of the North Pole, and north of the South Pole) as 30°.

For lunar outposts, we need not only water, and not only iron which is present everywhere on the Moon, but also basalt. An unrefined material out of which the lava flows that make up the Moon's "seas" is composed, basalt can be hewn, sculpted, and cast into useful things much more easily than we can make items out of steel and aluminum alloys.

Most importantly, cast basalt pipes are abrasion resistant. Given that moon dust is very abrasive, a cast basalt pipe operation should be industry #1, not steel, or aluminum, etc. Cast basalt can be used to make abrasion-resistant floor tiles, table and counter tops, seating, bath tubs, planters, and much more.

A new industry, basalt fiber composites, is already replacing rebar used in reinforcing concrete slabs with rockbar. And we predict many more uses of primary importance on the Moon.

This means that it makes no sense to start at the poles, at neither of which are there basalt resources. As for access to around the month sunlight, a line of solar power stations connected by cable from the western reaches of Sinus Roris to the eastern reaches of Mare Frigoris, would provide power for almost as long as the best north and south polar sites. ##

## GOING BACK TO THE MOON WITH PRIVATE ENTERPRISE

### NASA bets on Private Companies to Exploit Moon's Resources

<http://www.space-travel.com/reports/>

[NASA bets on private companies to exploit moons resources 999.html](http://www.space-travel.com/reports/nasa-bets-on-private-companies-to-exploit-moons-resources-999.html)

Feb 09, 2014 – NASA -- building on successful partnerships with private companies to resupply the International Space Station -- is now looking to private entrepreneurs to help exploit resources on the Moon. NASA proposing private companies take advantage of NASA's extensive know-how, its engineers and access to its installations to help design and build lunar robots.

But the Moon proposal -- **CATALYST** (Cargo Transportation and Landing by Soft Touchdown) -- would get no US government economic help.

Recent probes in orbit around the Moon's orbit have revealed evidence of water and other interesting substances on the surface, but to understand the extent and accessibility of these resources, we need to explore up close and sample thoroughly. Commercial lunar landing capabilities could help.

NASA is now working on an ambitious plan for humans to explore an asteroid and Mars, in the process, there will be opportunities to advance new technologies for use on the Moon. In 2013 NASA reached an agreement with Bigelow Aerospace to develop plans to build a lunar base using Bigelow's inflatable space modules.

#### Big money on the Moon

NASA-Commercial partnerships work "very well in lower orbit," said Bigelow's Michael Gold, referring to the ISS commercial contracts to re-supply the ISS. This arrangement should work just as well on the Moon, "And in the present economic climate, it only makes sense to leverage private sector investments and capabilities," he said. "This approach is cheaper than a standard space mission fully paid by the federal government, making it possible to carry out manned Moon missions within a decade,

The Moon has significant reservoirs of helium 3, which is rare on Earth and which could be developed into a clean energy fuel ideal for nuclear fusion. The soil is also rich in coveted rare earth elements heavily used in everyday electronics.

"There are a vast amount of opportunities for a wide variety of companies not only in America but across the globe," Gold insisted, emphasizing Europe and Japan, as well as the US Congress, are enthusiastic about a return to the moon.

John Logsdon, former director of the Space Policy Institute at George Washington University, said these private partnerships could be "a way of NASA getting back involved with the Moon without violating the president's policy that says we "as a government, we don't go back to the Moon." NASA chief Charles Bolden said last year his agency would not take the lead on a manned lunar mission, but wouldn't rule out the possibility of participating in one led by a private company or another country. ##



## Study on lunar crater counting shows Crowdsourcing effective, accurate tool

<http://www.space-travel.com/reports/>

[Study\\_on\\_lunar\\_crater\\_counting\\_shows\\_crowdsourcing\\_effective\\_accurate\\_tool\\_999.html](http://www.space-travel.com/reports/Study_on_lunar_crater_counting_shows_crowdsourcing_effective_accurate_tool_999.html)

<http://www.space.com/25200-citizen-science-counting-moon-craters.html>

<http://www.space.com/24788-moon-blast-boulder-sized-meteor-creates-131-foot-wide-crater-video.html>

March 14, 2014 –A new study led by the University of Colorado Boulder showed that as a group, volunteer counters who examined a particular patch of lunar real estate using NASA images did just as well in identifying individual craters as professional crater counters with five to 50 years of experience.

The study compared the results of eight professional planetary crater counters with several thousand amateur crater counters from every corner of the globe.

"We now have evidence that we can use the power of crowdsourcing to gather more reliable data from the Moon than we ever thought was possible before."

A paper on the subject was published online March 4 in the journal *Icarus*. The crater-counting effort was initiated by CosmoQuest, a citizen science Web project that contributes real science to NASA space missions through the use of volunteers.

The volunteers are now helping tally craters on Mercury and the asteroid Vesta.

Developed by Southern Illinois U. Edwardsville (SIUE) Assistant Professor Pamela Gay, also a study co-author, CosmoQuest includes educational features, forums, blogs, online hangouts and galleries. It even has a human versus machine contest pitting individual citizen scientists against computerized crater mapping programs. "Craters on the moon are important to scientists because they are a record of the cosmic mayhem that went on during the early formation of our solar system," Most scientists believe that period was like a giant, madhouse billiard game, with comets, asteroids, moons and planets randomly slamming into each other for hundreds of millions of years.

"The early solar system bombardment recorded on the lunar surface allows scientists to look backward in time to see the conditions early Earth likely endured," said Robbins. "As scientists, we not only want to know what events happened, but when."

The images under study by both the volunteer crater counters and the experts were taken by a camera onboard NASA's Lunar Reconnaissance Orbiter, launched in 2009. This project will help professional scientists spot hazards and safe havens for future moon missions.

Calculations through the extrapolation process indicate that there are some 500 million craters on the moon larger than about 11 meters (35 feet) across created by impacting objects. Unlike Earth, the Moon never had tectonic plate movements, erosion and has not experienced widespread volcanism for billions of years – processes that tend to "erase" geological features like impacts on Earth.

For the lunar crater-counting project, several images of small portions of the Moon were put online and the planetary science professionals and the citizen scientists were asked to identify craters in the images that were at least 18 or more pixels.

The area of the high-resolution images under study by the crater counters for the project was about 3.6 sq km (1.4 sq mi), 360 hectares (900 acres) roughly the area of 1,000 football fields.

Even the total craters counted by experts in a single image varied by as much as 100 percent, or a factor of two. But when averaged by group, the population of craters found by the experts and citizen scientists were statistically similar, said Robbins.

"Without this first step of verifying the accuracy of volunteer crater counters, there would be no point in continuing the project. Our study results mean we can now use the power of crowdsourcing to gather more data than we ever thought possible before." ##

## NASA Seeks Partnership Opportunities For Commercial Lunar Landers

{ FULL TEXT ] [http://www.nasa.gov/lunarcatalyst\\_9](http://www.nasa.gov/lunarcatalyst_9)

<http://www.space-travel.com/reports/>

### [NASA Announces Partnership Opportunities for US Commercial Lunar Lander Capabilities 999.html](#)

Jan 16, 2014 – Building on the progress of NASA's partnerships with the U.S. commercial space industry to develop new spacecraft and rockets capable of delivering cargo, and soon, astronauts to low Earth orbit, the agency is now looking for opportunities to spur commercial cargo transportation capabilities to the surface of the Moon.

NASA has released an announcement seeking proposals to partner in the development of reliable and cost-effective commercial robotic lunar lander capabilities that will enable the delivery of payloads to the lunar surface. Such capabilities could support commercial activities on the Moon while enabling new science and exploration missions of interest to NASA and the larger scientific and academic communities.

NASA's new Lunar Cargo Transportation and Landing by Soft Touchdown (Lunar CATALYST) initiative calls for proposals from the U.S. private sector that would lead to one or more no-funds exchanged Space Act Agreements (SAA). NASA's contribution to a partnership would be on an unfunded basis and could include the technical expertise of NASA staff, access to NASA center test facilities, equipment loans, or software for lander development and testing.

"As NASA pursues an ambitious plan for humans to explore an asteroid and Mars, U.S. industry will create opportunities for NASA to advance new technologies on the moon," said Greg Williams, NASA's deputy associate administrator for the Human Exploration and Operations Mission Directorate. "Our strategic investments in the innovations of our commercial partners have brought about successful commercial resupply of the International Space Station, to be followed in the coming years by commercial crew. Lunar CATALYST will help us advance our goals to reach farther destinations."

The Moon has scientific value and the potential to yield resources, such as water and oxygen, in relatively close proximity to Earth to help sustain deep space exploration. Commercial lunar transportation capabilities could support science and exploration objectives, such as sample returns, geophysical network deployment, resource prospecting, and technology demonstrations. These services would require the ability to land small (66 to 220 pound, or 30 to 100 kilogram) and medium (551 to 1,102 pound, or 250 to 500 kg) class payloads at various lunar sites.

"In recent years, lunar orbiting missions, such as NASA's Lunar Reconnaissance Orbiter, have revealed evidence of water and other volatiles, but to understand the extent and accessibility of these resources, we need to reach the surface and explore up close," said Jason Crusan, director of Advanced Exploration Systems at NASA Headquarters in Washington. "Commercial lunar landing capabilities could help prospect for and utilize these resources."

Lunar CATALYST supports the internationally shared space exploration goals of the Global Exploration Roadmap (GER) NASA and 11 other space agencies around the world released in August. The GER acknowledges the value of public-private partnerships and commercial services to enable sustainable exploration of asteroids, the Moon and Mars.

Commercial lunar cargo transportation systems developed through Lunar CATALYST could build on lessons learned throughout NASA's 50 years of spaceflight. New propulsion and autonomous landing technologies currently are being tested through NASA's Morpheus and Mighty Eagle projects.

NASA will host a pre-proposal teleconference on Monday, January 27, during which proposers will have an opportunity to ask questions about the announcement. Proposals from industry are due by March 17. The announcement of selections is targeted for April with SAAs targeted to be in place by May.

The Advanced Exploration Systems Division in NASA's Human Exploration and Operations Mission Directorate manages Lunar CATALYST. Advanced Exploration Systems pioneers new approaches for rapidly developing prototype systems, demonstrating key capabilities and validating operational concepts for future human missions beyond Earth orbit.

As NASA works with U.S. industry to develop the next generation of U.S. spaceflight services, the agency also is developing the Orion spacecraft and the Space Launch System (SLS), a crew capsule and heavy-lift rocket to provide an entirely new capability for human exploration. Designed to be flexible for launching spacecraft for crew and cargo missions, SLS and Orion will expand human presence beyond low-Earth orbit and enable new missions of exploration across the solar system, including to a near-Earth asteroid and Mars. ##

**EDITOR: This complements recent initiatives by the Google Lunar X-Prize, and by Golden Spike Corp.**

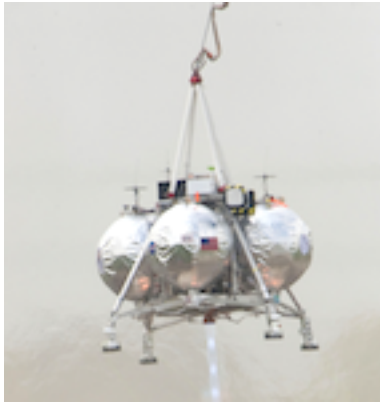
## Wanted: Private Robot Moon Lander Ideas for NASA

Jan 27, 2014 – NASA is looking for **innovative new ideas for robotic missions to the Moon**.

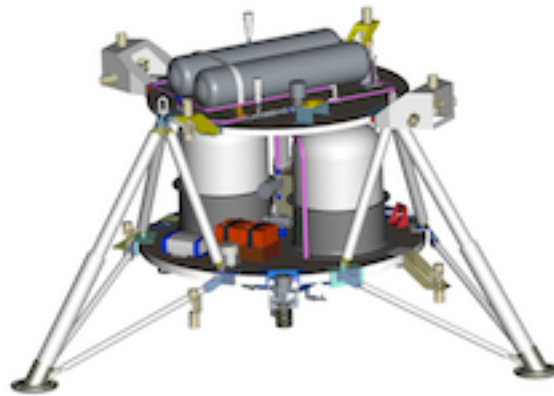
Private spaceflight companies may have the right stuff to help out. The space agency is rolling out its new **Lunar Cargo Transportation and Landing by Soft Touchdown initiative (Lunar CATALYST)** to give private companies a chance to develop robotic moon landers with help from NASA. The agency won't provide any funding for commercial projects, but private companies selected for the program will have access to a range of NASA perks. The goal is to support lander development.

NASA will offer technical expertise, access to our facilities, loan of equipment or software at no cost to those partners to help them accelerate their capabilities to get a landing capability that's commercially viable for them."

Lunar landing development for commercial purposes — like Moon mining — could help with new science and technology advancement and could also serve as a stepping-stone for getting into deeper destinations in space like Mars. Private companies have already shown interest in the new partnership.



**Project Morpheus tether test**



**NASA's Mighty Eagle Lander**

Companies chosen to participate could have access to NASA's Mighty Eagle and the Morpheus lander — two prototype landers that could be launched to explore the Moon or other cosmic objects.

"It's one thing for NASA to do it once, but it's a whole other thing to build upon and build an entire ecosystem of suppliers out there."

The space agency is currently working with private companies under the Commercial Crew vehicle program and supporting the Google Lunar X-Prize which is also encouraging rethinking of all aspects of lunar landers.

The deadline to submit finalized proposals for the Lunar CATALYST initiative is March 17, 2014.

<http://www.nasa.gov/lunarcatalyst/#.UuZo5WQo7KF>

## Moon Rovers Planned for Golden Spike Commercial Lunar Exploration Project

Jan 2, 2014 – <http://www.space.com/23946-golden-spike-private-moon-rover-designer.html>

The commercial spaceflight company Golden Spike announced in December 2012 that it planned to fly private 2-person missions to the Moon by 2020. It has now teamed up with New York-based Honeybee Robotics to design robotic rovers for these expeditions, to boost "the science output."

Honeybee Robotics has been designing planetary sampling devices for clients including NASA and the US Department of Defense for more than 25 years: It designed the rock abrasion tool for NASA's Mars Exploration Rovers Spirit and Opportunity, as well as the icy soil acquisition scoop for the NASA's Phoenix Mars lander, and the sample manipulation system and dust removal tool for the Curiosity rover.

Preliminary tests of the rover design could come in mid-year.

Golden Spike missions had initially been priced at \$1.5 billion per person, now estimates that the cost could be cut in half, down to about \$750 million with the help of media coverage and sales of merchandising rights of the missions. Potential individual customers include leaders of nations, large corporations, and wealthy individuals. ##

Video describing a Golden Spike Mission:

[www.space.com/18801-private-company-wants-bootprints-on-the-moon-by-2020-video.html](http://www.space.com/18801-private-company-wants-bootprints-on-the-moon-by-2020-video.html)



## 5 Private Moon-Race Teams Compete for Bonus \$6 Million

<http://www.space.com/24736-google-lunar-xprize-bonus-prize.html>

FEBRUARY 19, 2014: Landing on the Moon is no easy feat, and five teams competing for the \$30 million Google Lunar X Prize might get a little more money to help them send their probes to the lunar surface.

**Astrobiotic, Moon Express, Team Indus, Hakuto and Part-Time-Scientists** are all in the running to win "milestone prizes" later this year, [Google Lunar X Prize](#) officials announced today (Feb. 19). The total purse for the awards is **\$6 million** with the teams competing in three different categories for the funds, X Prize officials said.

Each company's ultimate goal is to ready its probe for launch by Dec. 31, 2015 in order to have a shot at winning the overall prize by being the first in the competition to

**“move 500 m (1,650 ft) on the Moon’s surface and send video, images and data back to Earth”**

The milestone prizes are designed to help teams overcome financial problems they could be facing while trying to compete. "Because we have teams from such diverse backgrounds, they are often able to think of a solution that a company that may have grown up in the more traditional space engineering sense may not be even aware exists."

The three categories chosen for the milestone prizes represent major hurdles that competing teams must overcome before being able to land on the Moon. The categories are:

- **Landing System Milestone Prize:** \$1 million per team — "based on the hardware and software that enables a soft landing on the moon."
- **Mobility Subsystem Milestone Prize:** \$500,000 per team — "based on the mobility system that allows the craft to move 500 meters after landing."
- **Imaging Subsystem Milestone Prize:** \$250,000 per team — "based on producing 'Mooncasts' consisting of high-quality images and video on the lunar surface."

US-based teams **Astrobiotic** and **Moon Express** are both working toward winning the milestone prize money in all three categories. Germany's **Part-Time-Scientists** is competing for the mobility subsystems and the imaging subsystems prizes. India's **Team Indus** is working on the landing systems and imaging subsystems prizes. Japan-based **Hakuto** is in the running for the mobility subsystem prize.

In total, teams submitted 33 proposals for the three categories, and 11 proposals from five teams were selected. If each team completes a series of tasks decided on by the teams and a panel of nine expert judges before September 2014, it will receive the set amount of prize money regardless of whether or not the other teams accomplish their goals.

There are currently 18 teams working toward winning the \$30 million prize. ##

## Could we build Space Elevators on the Moon? (to L1 and/or L2)

March 4, 2014 - **Futuristic Moon Elevator Idea Takes Aim at Lunar Lifts** by Leonard David

<http://www.space.com/24905-moon-elevator-lunar-exploration-liftport.html>

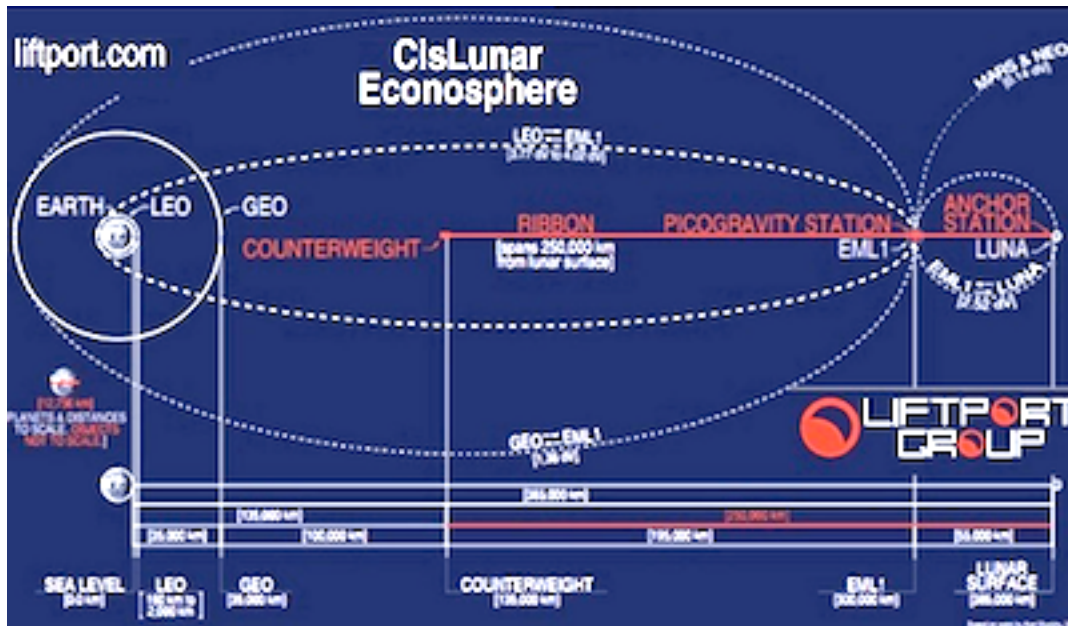
<http://www.space.com/24919-lagrangian-elevator-to-the-moon-is-it-possible-video.html>

An elevator to the Moon might not be as crazy as it sounds [\[Editor, or as easy.\]](#)

A Moon-based elevator to space could radically reduce the costs and improve the reliability of placing equipment on the lunar surface and make the transport of supplies and materials from the surface of the Moon into the Earth's orbit and vice versa possible. Valuable resources could be extracted from the Moon, then sent into Earth orbit more easily than if they were rocketed from the Earth's surface. You can see a video of how a Moon elevator to space might work. <http://www.space.com/24919-lagrangian-elevator-to-the-moon-is-it-possible-video.html>

According to the LiftPort Group of Seattle, WA, a LiftPort strategic framework would establish an operational Lunar Space Elevator Infrastructure (LSEI), involving commercial, off-the-shelf technology, a Sputnik-like simplicity and a single heavy-lift launch solution.

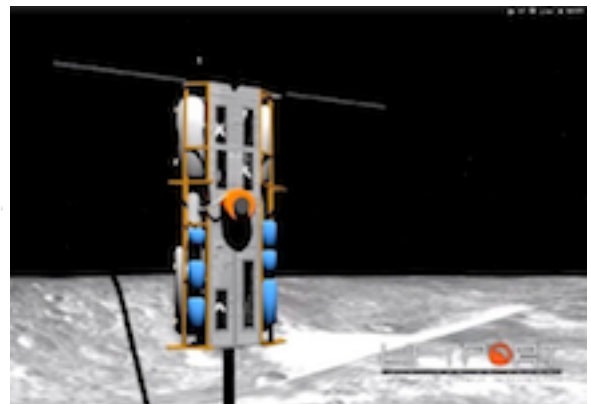
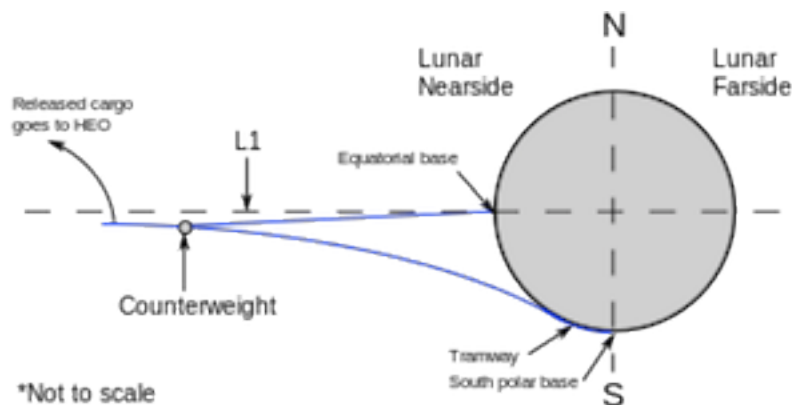
Full size image below: <http://i.space.com/images/i/000/037/325/i02/liftport-4.jpg?1393945948>



**Infrastructure:** LiftPort's concept calls for using a climbing vehicle that scoots up and down a ribbon-shaped, tethered cable that's part of an anchor station secured to the airless moon, making soft landings on the moon possible. A rocket launched from Earth to a Lagrange Point PicoGravity Lab, where cargo is transferred to the robotic lifter and gently delivered to the Moon's surface.

A lunar elevator could soft-land equipment and people on the Moon's surface. Transport of three-dozen people to the Moon per year would be attainable in the early years of the elevator's operation.

**Steady progress:** Michael Laine, president of the LiftPort Group, says renewed attention to the Moon is encouraging the Group to further develop their concepts, citing NASA's newly announced Lunar Cargo Transportation and Landing by Soft Touchdown, Lunar CATALYST program, intended to spur commercial cargo transportation capabilities to the surface of the Moon. Funds from a recent Kickstarter campaign have enabled LiftPort to focus on the lunar elevator idea.



**Challenges ahead:** The "credo" on the LiftPort website maintains: "**There is a profound difference between difficult, very, very hard, and impossible.**" Elevators on Mars and Earth would be more demanding and further off. "The prospects for the Earth space elevator are brighter now ... but there are challenges remaining," said Jerome Pearson, president of STAR, Inc., based in Mount Pleasant, S.C. H

- Producing the vast quantities of high-strength carbon nanotube composites required
- Dynamics [Python Dynamics] of the 100,000-km-long structure
- Problems of debris in low Earth orbit that could destroy the space elevator ribbon.

**Editor's comment:** While a lunar elevator would not have to content with weather on Earth's surface interfering with safe arrival and departure, or debris in Earth's orbit,

There is a problem to be addressed: the ever fluctuating Moon-L1 distance.

Further, the elevator's small daily shipping capacity will quickly be surpassed by the tonnages needed. On Earth, we could in time have many elevators all around the equator, whereas on the Moon, there are only two locations, one each on the nearside and the farside, ##

## The Moon is “wetter” than we thought

[http://www.space-travel.com/reports/A\\_Wet\\_Moon\\_999.html](http://www.space-travel.com/reports/A_Wet_Moon_999.html)

March 26, 2014 – The Moon's status as a “dry” rock in space has long been questioned. Theories abound as to the source of the H<sub>2</sub>O in the lunar soil, including delivery of water to the Moon by comets.

### New analyses of lunar soil samples

This week, Tartese et al announced in **Geology**, that new analyses of lunar soil samples demonstrates that basalts from the Moon's mantle contain hydrogen from water indigenous to Earth. Their work is “challenging the paradigm of a “dry” Moon, and arguing that **some portions of the lunar interior are as wet as some regions of the Earth's mantle.**

The Moon's origin is believed to be the Earth itself, which gave rise to the Moon when a Mars-sized object (now dubbed “Theia” – [www.wikipedia.org/wiki/Giant\\_impact\\_hypothesis](http://www.wikipedia.org/wiki/Giant_impact_hypothesis)) impacted our planet around 4.5 billion years ago. The Earth's mantle is known to be partially water.

This finding raises the odds that the Moon may have a partly-aqueous core today. These results promise that at some time in the past there was water in the Moon's mantle, inherited from an ancestral proto-Earth, which rose to the surface in magma, and became **trapped in crystals called apatites.**

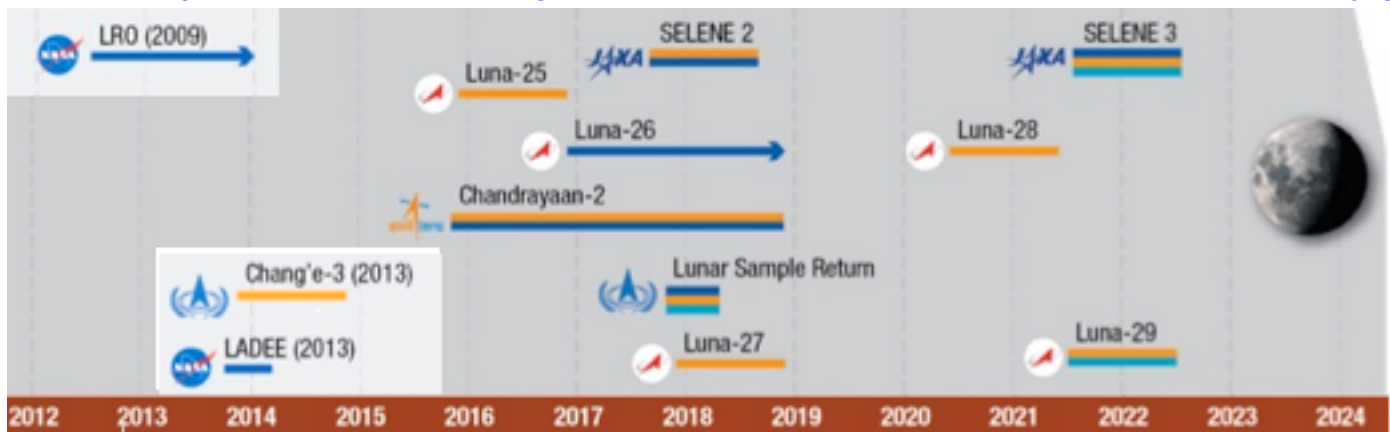
**How much water remains, and how it can be accessed to support human habitation, will be a subject of ongoing study.**

The paper, “**Apatites in lunar KREEP basalts: to understanding the H isotope systematics of the Moon,**” was published in the journal *Geology* under lead author Romain Tartese

**Editor:** This is good news for those who foresee appreciable lunar settlements as part of a greater “Earth-Moon Economy” in the near future.

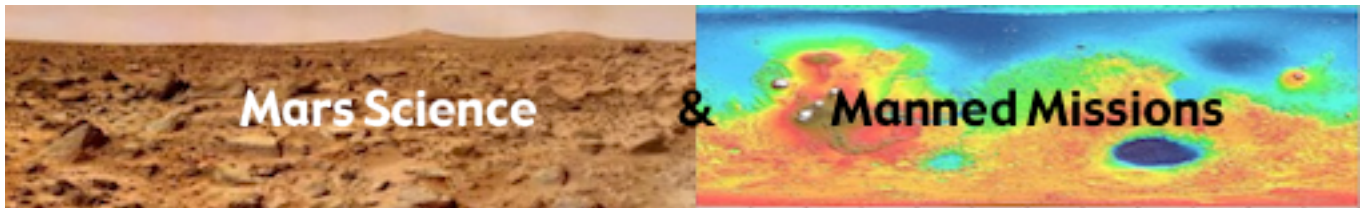
## Moon Missions on the Horizon

<http://www.globalspaceexploration.org/wordpress/wp-content/uploads/2013/12/lunarrobotics.jpg>



### On the horizon:

- Reports on NASA's LADEE Mission
- Reports on Chang'e-3 lander and Rover
- Reports on Lunar Reconnaissance Orbiter
- Progress Reports on Google Lunar X-Prize teams



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

## MARS ANALOG EXERCISES

### Mars Desert Research Station (MDRS) 2013 – 2014 Field Season Crews

Dec. 7, 2013 – May 10, 2014 – <http://mdrs.marssociety.org> – Hanksville, Utah, US

\*Schedule and crew listing subject to change.



Mars Desert Research Station (and Green Hab) at night

Crew 131	Embry–Riddle Aeronautical University (Dec. 7 – 22, 2013)
Crew 132	Mars Society Crew I (Dec. 21, 2013 – Jan. 5, 2014)
Crew 133	University of North Dakota (Jan. 4 – 19, 2014)
Crew 134	Team Mars UK (Jan. 18 – Feb. 2, 2014)
Crew 135	RAR Crew (Feb. 1 – 16, 2014)
Crew 136	Mission to Mars UCL (Feb. 15 – Mar. 2, 2014)
Crew 137	Team Nippon (Mar. 1 – 16, 2014)
Crew 138	Mars Society Crew II (Mar. 15 – 30, 2014)
Crew 139	Lone Star Highlanders (Mar. 29 – Apr. 13, 2014)
Crew 140	Team Peru II (Apr. 12 – 27, 2014)
Crew 141	Mars Society Crew III (Apr. 26 – May 10, 2014)

## MARS PROBES TO COME

### NASA Receives Mars 2020 Rover Instrument Proposals for Evaluation

<http://www.jpl.nasa.gov/news/news.php?release=2014-017>

**January 21, 2014** – NASA has received 58 proposals for science and exploration technology instruments to fly aboard the agency's next Mars rover in 2020, twice the usual number submitted for instrument competitions in the recent past, an indicator of the extraordinary interest in exploration of the Red Planet.

NASA is beginning a thorough review to determine the best combination of science and exploration technology investigations for the mission. The final selections should be made in the next five months. It expects to select an instrument suite that will return exciting science and advance Mars exploration."

Competition for Mars 2020 research proposals opened in September and closed January 15. Several NASA facilities, academia, industry, research laboratories and other government agencies submitted proposals. International partners submitted seventeen proposals.

The Mars 2020 mission has several high-priority planetary science goals and will be an important step toward meeting the challenge of sending humans to Mars in the 2030s. "The mission will conduct geological assessments of the rover's landing site, determine the habitability of the environment, search for signs of ancient Martian life, and assess natural resources and hazards for future human explorers."

The new instruments will help identify and select a collection of rock and soil samples for potential return to Earth in the future, one of the highest-priority objectives of the 2011 Planetary Science Decadal Survey. Sample analysis in laboratories on Earth will help determine if life existed on Mars and help plan for human exploration missions to the planet.



Two rover goals are to help design manned expeditions to meet the hazards of Martian dust and demonstrate collection of carbon dioxide from Mars' atmosphere, for producing oxygen and rocket fuel. The selected instruments will be placed on a rover similar to Curiosity, using its proven landing system and chassis design will ensure mission costs and risks are minimized as much as possible.

In 2016, a Mars lander mission called InSight will take the first look into the deep interior of Mars. The agency also is participating in the European Space Agency's 2016 and 2018 ExoMars missions, providing "Electra" telecommunication radios to ESA's 2016 orbiter and a critical element of the premier astrobiology instrument on the 2018 ExoMars rover.

More information: <http://www.nasa.gov/mars> ##

## NASA, France Team Up for 2016 Mars Lander "InSight" Mission

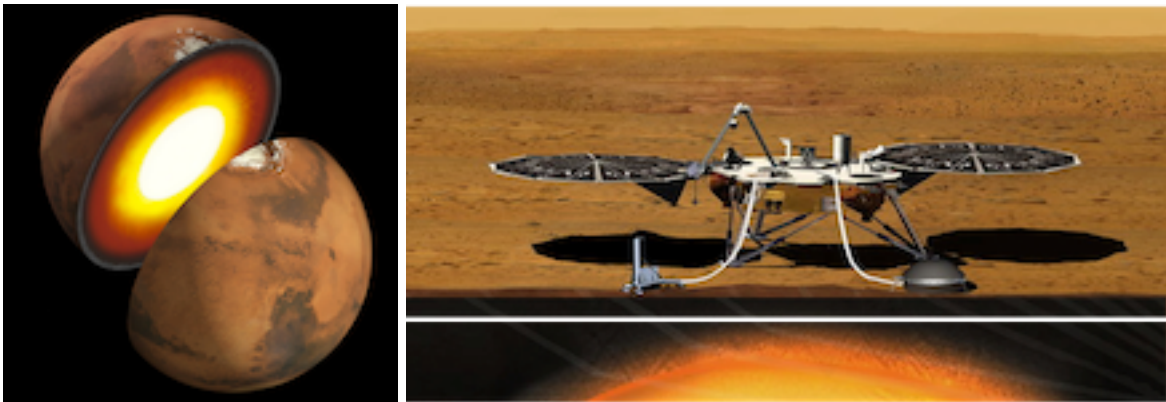
<http://www.space.com/24660-nasa-france-mars-lander-2016.html>

<http://www.space.com/17199-nasa-mars-insight-lander-mission-gallery.html>

<http://www.dailymail.co.uk/sciencetech/article-2191399/Nasa-launch-Mars-mission-2016-Robot-sent-reveal-red-planets-interior.html>

Feb 17, 2014 Space officials from the United States and France signed an agreement this week to work together on a NASA's next Mars lander mission set to launch in 2016 to peer deep into the core of the Red Planet.

The **InSight Mars Lander** — short for **I**nterior exploration using **S**eismic Investigations, **G**eodesy, and **H**eat Transport) — is currently scheduled to fly in March 2016 and touch down on Mars six months later.



The lander will spend two years study the Mars' interior makeup, which could help scientists understand the building blocks of terrestrial planets like Earth.

NASA Administrator Charles Bolden and Jean-Yves Le Gall, president of the National Center of Space Studies of France (CNES), signed an implementing deal pledging their cooperation on the project.

Spacecraft now studying the Red Planet like NASA's Mars Rover **Curiosity** have largely focused on surface features like rocks and soil to piece together a history of Mars. But NASA officials say **InSight will probe much deeper, with geophysical instruments that can study the properties of the Red Planet's core, mantle and crust as well as heat flow from the interior.**

The probe could help scientists determine whether Mars has a **liquid or solid core** and why its crust **doesn't seem to have drifting tectonic plates like those on Earth.**

NASA's Jet Propulsion Laboratory in Pasadena, Calif., will lead the InSight mission under principal investigator principal investigator, Bruce Banerdt. CNES is building one of the lander's key tools: the Seismic Experiment for Interior Structure instrument, or **SEIS**, which will explore Martian tectonic activity and meteorite impacts. ##

### More links:

[http://insight.jpl.nasa.gov/newsdisplay.cfm?Subsite\\_News\\_ID=33931](http://insight.jpl.nasa.gov/newsdisplay.cfm?Subsite_News_ID=33931)

<http://www.jpl.nasa.gov/missions/insight/>

<http://en.wikipedia.org/wiki/InSight>

### Questions to be answered

- applications - geothermal heat/energy systems, earthquake dangers
- subsurface water (not ice) reservoirs
- accompanying oil and other fossil reservoirs which would be evidence of ample/long lasting life
- calcareous deposits Editor

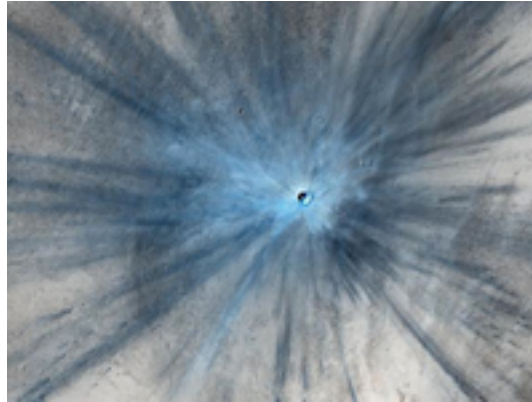
## Fresh Crater on Mars Spotted by NASA Reconnaissance Orbiter

Feb 6, 2014 - <http://www.space.com/24575-fresh-mars-crater-nasa-spacecraft.html>

A NASA Mars orbiter has snapped a stunning photo of a fresh Martian crater that was apparently gouged out of the the surface in just the last three years or so.

NASA's Mars Reconnaissance Orbiter's powerful HiRISE camera had captured the photo on Nov. 19, 2013, but the agency did not release the photo until February 5th.

Scientists calculated that feature formed sometime between July 2010 and May 2012, because other MRO observations show big changes in the area between those two dates.



Full size: <http://i.space.com/images/i/000/036/681/original/mars-new-impact-crater-mro.jpg?1391634789>

**Editor's observation:** looks like the impactor hit "straight on" or perhaps slightly from the lower right

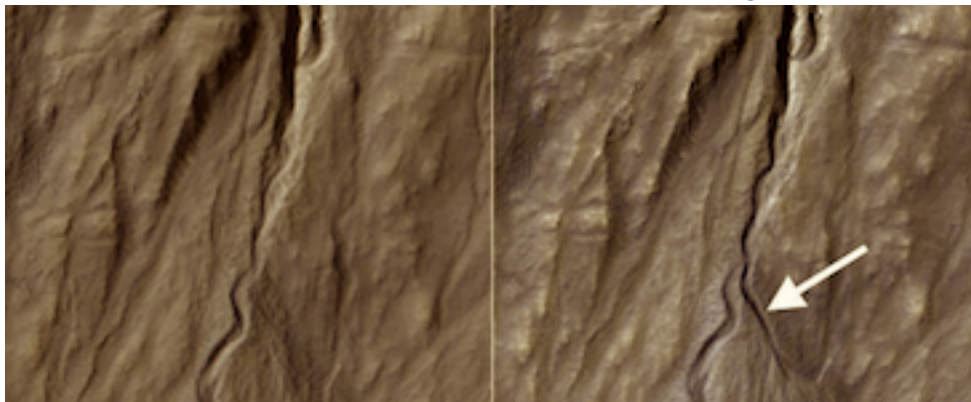
The crater sits at 3.7°~ and 53.4°W on Mars and is about 30 m (100 ft) across and is surrounded by a large, rayed blast zone, "Because the terrain where the crater formed is dusty, the fresh crater appears blue in the enhanced color of the image, due to removal of the reddish dust in that area." The impactor ejected material as far as 15 KM (9.3 mi) away from the crater.

Mars has been bombarded by space rocks for eons. Without a thick atmosphere such as Earth's, more asteroids reach the ground largely intact

Before-and-after imaging that brackets appearance dates of fresh craters on Mars has indicated that impacts producing craters at least 12.8 feet (3.9 meters) in diameter occur at a rate of over 200 per year globally, but few of the scars are as dramatic in appearance as this one. ##

## NASA's Mars Reconnaissance Orbiter discovers new Gully/Channel

March 20, 2014 - <http://www.space.com/25147-new-mars-gully-nasa-photo.html>



This pair of before (left) and after (right) images from the High Resolution Imaging Science Experiment (HiRISE) camera on NASA's Mars Reconnaissance Orbiter documents the formation of a substantial new channel on a Martian slope **between Nov. 5, 2010, and May 25, 2013.**

The location is on the inner wall of a crater at 37.45 degrees south latitude, 222.95 degrees east longitude, in the Terra Sirenum region. Image released March 19, 2014 - color altered to Marslike sepia tones by editor. ##

## 'Faxing' Life from Mars: Craig Venter's Wild, Digital Space Exploration Idea

March 4, 2014 – <http://www.space.com/24923-faxing-life-from-mars-craig-venter.html>

If NASA probes ever find life on Mars, it may be possible to beam Martian DNA back to Earth, according to an enticing new idea growing in popularity. The idea of "faxing" life from Mars is an enticing prospect, spurred on by Craig Venter, famous for his early sequencing of the human genome.

He proposes that researchers analyze Martian DNA on the Red Planet and then radio back that sequence to synthesize the DNA on Earth. This is the subject of a book he published last year called "**Life at the Speed of Light: From the Double Helix to the Dawn of the Digital Age.**"

Founded by Venter, the J. Craig Venter Institute (JCVI) in San Diego and Rockville, Md., is home to some 250 scientists and staff with expertise in human and evolutionary biology, genetics, bioinformatics/informatics, information technology, high-throughput DNA sequencing, genomic and environmental policy research, and public education in science and science policy.

Venter's work to detect and decode DNA could mean searching for, finding, then e-mailing biology, say found on Mars, via a "Digital Biological Converter." That is, **build Red Planet Life on Earth so scientists can get an extraterrestrial eyeful without turning in travel miles.**

This notion could offer a way around an expensive return specimen effort and quell paranoia of nasty creepy crawlers from Mars eating away at Earth's biosphere?

### Word-skill marketing

Lynn Rothschild, an evolutionary biologist-astrobiologist-synthetic biologist at NASA's Ames Research Center cautions that this would increase the chance of problems since we would be making something that uses the terrestrial operating system. Yet the idea of going to a computer — asking that DNA be printed by sending off digital information — is what most molecular labs do today when they order DNA from a synthesis company who then makes the DNA based on the inputted sequence. She questions the assumption that life on Mars would have the same DNA coding system that underlies life on Earth.

[Editor, Life anywhere would seem to involve some coding system which involves molecules that direct the growth and development of the molecules in that specific life form. It would seem that the elements and the way they are arranged in DNA would work the same anywhere in our universe.]

### Outbound drugs

If an astronaut en route to Mars or already on Mars needed a drug, the information to make the drug could be sent to the astronauts who could then have the instructions printed into DNA, put the DNA in a production cell such as yeast or a bacterium, or even a plant, and have it made that way rather than carrying everything up with them, Rothschild said. This idea is now a project of NASA's innovative Advanced Concepts (NIAC) program. This not only avoids the cost of shipment to Mars but also the risk of drugs losing effectiveness over time

### Magical machines

Astrobiologist Penny Boston, a professor at the New Mexico Institute of Mining and Technology worries that life forms produced by DNA information sent from Mars could be harmful to life here. Boston feels that "we are still stuck with the need to study the actual organism, whether it's transmitted from Mars or transmitted from across the room."

### Key steps

(1) Find life on Mars. (2) Hope that life on Mars uses DNA/RNA that can be sequenced. (3) Sequence and send it home. The most likely sequence to be sent home from Mars would be one of the organisms that contaminate the spacecraft before it leaves Earth.

"They will have to work hard to make sure that they aren't sending home an organism that is already here," he said, "although that might be an interesting, if costly, exercise to make the point that there is more than one way to come home again from Mars."]

### Narrow set of assumptions

"Craig Venter's proposal is based on the very narrow set of assumptions that Mars life will look exactly like Earth life." It presumes that Mars life will have DNA, and that the Mars DNA can be read and interpreted correctly by Earth cellular machinery, Conley emphasized. ##

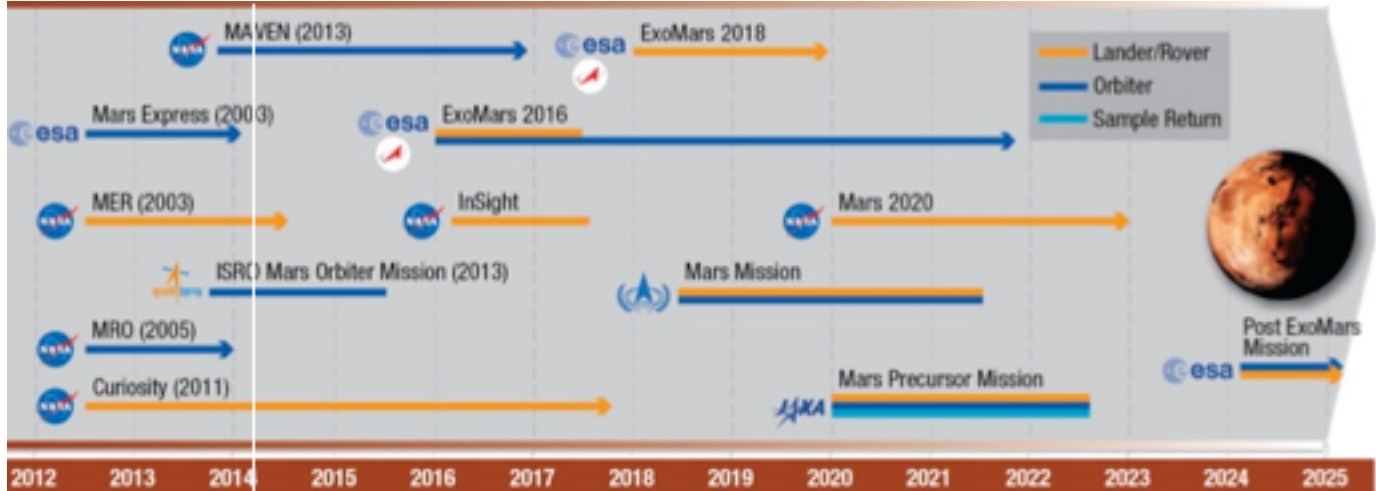
[Editor: that assumption seems to be obviously correct. Atoms behave the same no matter where they are. And if it proves to be true that Earth life arose from organic material transported here by meteorite chunks blasted off of Mars by some impact, then we could assume that the DNA system on both worlds would be one and the same.]



## MARS MISSION NEWS

### Mars Missions on the horizon

[www.globalspaceexploration.org/wordpress/wp-content/uploads/2013/12/lunarrobotics.jpg](http://www.globalspaceexploration.org/wordpress/wp-content/uploads/2013/12/lunarrobotics.jpg)



## MARS SCIENCE NEWS

### Ancient Mars May Have Been Habitable for Hundreds of Millions of Years

<http://www.space.com/24386-mars-could-support-life-opportunity-rover.html>

<http://news.yahoo.com/ancient-mars-may-habitable-hundreds-millions-years-192336149.html>

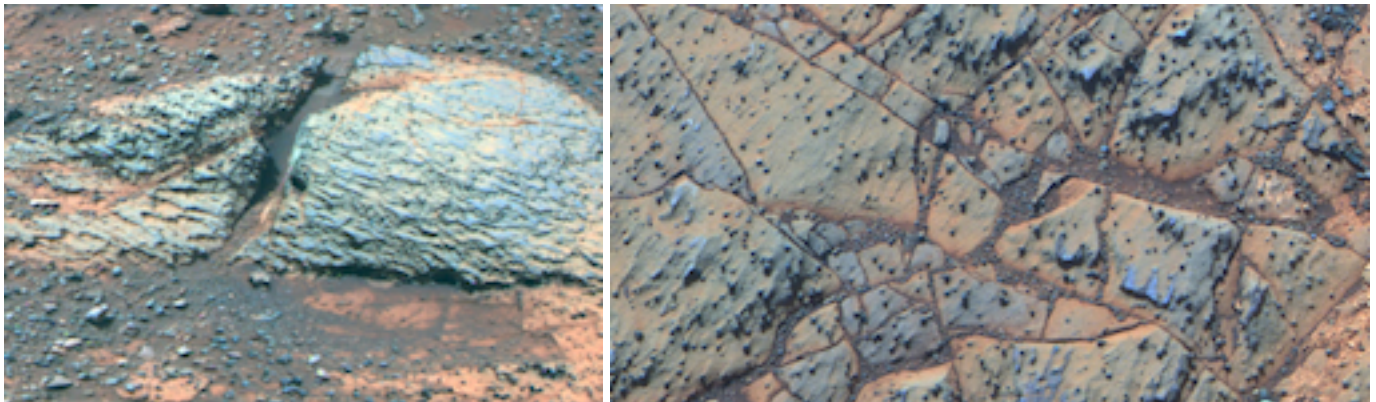
<http://www.space.com/10014-rover-tracks-dumb-luck-opportunity-meridiani.html> - video

<http://www.space.com/20193-mars-could-have-supported-life-nasa-finds-video.html>

January 23, 2014 – Mars may have once been capable of supporting microbial life for hundreds of millions of years in the distant past, new findings from the long-lived Red Planet rover Opportunity suggest.

NASA's Opportunity rover, which celebrated 10 years of Mars exploration Jan. 24, Rocks examined by the ten-year old rover show evidence that benign, nearly neutral-pH water flowed on Mars around 4 billion years ago. These results complement recent work of NASA's bigger, newer Curiosity rover, which discovered a potentially habitable lake and groundwater system in a different Martian locale dating from about 3.7 billion years ago. Primitive organisms may have been able to survive on Mars for long stretches during the same period that life was getting a foothold on Earth.

There remain lots of questions: did life spread globally on Mars or only “here and there” regionally. And did life survive continuously through that period?



### Studying ancient rocks

Opportunity landed on Mars Jan. 24, 2004, three weeks after its twin, Spirit. Both robots were tasked with 90-day missions to seek out signs of past water activity on Mars. Spirit was declared dead in 2011, but Opportunity is still going strong. The rover made the new discovery at an outcrop on the rim of 22 km (14 mi) wide Endeavour Crater, in August 2011<sup>42</sup>



Meanwhile, NASA's Mars Reconnaissance Orbiter spotted exposed, aluminum-rich clay minerals at a site along the rim called Matijevic Hill. Such clays generally form in the presence of benign, mildly acidic water, so Opportunity was directed to check out that rock formation.

There Opportunity encountered the oldest rocks it had yet found on Mars. Fine-grained, layered rocks in the Matijevic outcrop date from Mars' Noachian period, making them perhaps 4 billion years old – such numbers have large uncertainties. These clay-enriched rocks are studded with BB-size "spherules" and cut by numerous fractures, through which mildly acidic to mildly oxidizing water flowed long ago.

These ancient rocks predate the impact that created Endeavour Crater, and they're covered in most places by younger material that bears the signature of hyper-salty and much more acidic water — the signature, in other words, of a much less hospitable Mars. So the conditions for life were present for only a limited time, but that could have been as much as several hundred million years, way back.

### **Collaborating evidence from Curiosity**

Curiosity was designed to extend and advance the discoveries of Spirit and Opportunity and to do this, it carries 10 different science instruments designed to specifically to determine if the Red Planet could ever have supported microbial life.

The month before, the Curiosity team announced that an area near the rover's landing site harbored a large, shallow and potentially habitable lake system and its feeder streams that likely existed about 3.7 billion years ago, or even a bit more recently.

### **The Martian surface's window of habitability**

Liquid water cannot exist for long periods on the surface of today's Mars, with an atmosphere much thinner than 3.7–4 billion years ago. So this evidence of life on Mars eons ago in itself does not leave the door open for discovery of life forms still existing on the planet. "But we don't know, at this point, with just two examples." Stay tuned! ##

### **Editor's comment:**

If this is proven, that Mars today does not have any indigenous life forms, then that should mean that extreme "Planetary Protection" protocols, to prevent humans from "infecting and harming indigenous life forms" and vice versa, to prevent human Mars explorers from "bringing Martian pathogens back to Earth against which humans had no defense" are both quite unnecessary.

But would "our own" pathogens destroy the Martian evidence of life forms already extinct for billions of years? Not likely! Yes, we need to be careful, but let's cut the 1950-ish Sci-fi "Andromeda Strain" hysteria.

### **A lesson from our own history:**

Yes, when Europeans first came to the Americas, they brought with them smallpox, syphilis, and other diseases against which native American populations had no defense. And vice versa. But today we are all alive and adjusted. And so it has been from the beginning.

Humans should be free to settle Mars and introduce life forms to provide food, clothing, pharmaceuticals, etc. At the same time, areas where our robotic precursors have found evidence of past life could be declared "restricted sanctuaries - robots only," at least until such a time as we feel sure that we have learned from the evidence there, all there is to learn.

And, if it is proven that Earth Life is the offspring of "microbes from Mars," then it becomes a matter of destiny to return and do for Mars what it could not do for itself. ##

## **Meteorite May Harbor Evidence of Mars Life: Study**

February 25, 2014 – <http://www.space.com/24816-mars-life-meteorite-debate.html>

Have signs of ancient Martian life been found inside a Red Planet meteorite? A team of scientists says that microscopic tunnels and carbon-rich spherules that stud the interior of a Martian meteorite known as Yamato 000593 may have been formed by Red Planet organisms long ago.



Full size: [www.space.com/images/i/000/033/447/original/ALH84001.jpg?1381358116](http://www.space.com/images/i/000/033/447/original/ALH84001.jpg?1381358116)

The famous Martian meteorite ALH 84001 [above] contains a "fossil" that was ruled out as life because of its small size. But it could still be an autocell — a precursor to life. The new study, published in the February issue of the journal *Astrobiology*, does not claim that Yamato 000593 harbors conclusive evidence of life on Mars. But the rock may indeed contain something truly special

"We cannot exclude the possibility that the carbon-rich regions in both sets of features may be the product of abiotic mechanisms; however, textural and compositional similarities to features in terrestrial samples, which have been interpreted as biogenic, imply the intriguing possibility that the Martian features were formed by biotic activity."

<http://online.liebertpub.com/doi/full/10.1089/ast.2011.0733>

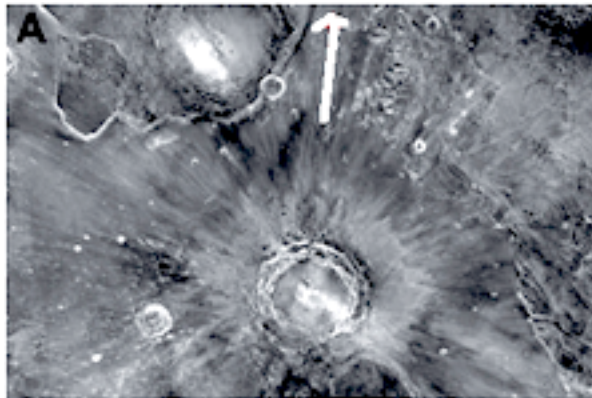
Eighteen years ago, researchers announced that they had found evidence of possible Martian lifeforms in a different meteorite, known as Allan Hills 84001 (ALH 84001). Doubters argued that ALH 84001's "nanofossils" could be abiotic in origin.

Similar scrutiny and skepticism has been voiced about the new discovery. The research team will expand its investigation of the 13.5 kg (30-lb) Yamato 000593 meteorite, which appears to have been formed about 1.3 billion years ago on Mars and landed in Antarctica a maximum of 10,000 years ago, after being blasted off Mars by an impactor. ##

## Big Mars Impact Gave Earth Most of Its Martian Meteorites

March 6, 2014 – <http://www.space.com/24962-mars-meteorites-single-impact.html>

According to a new study, the ricochet from a huge meteorite impact on Mars just five million years ago blasted toward Earth many of the rocks (found on Antarctic ice sheets) that scientists have been studying to learn more about Mars. That impact left a 55 km (34-mi) wide gouge on Mars called **Mojave Crater** and is the source of all "shergottite" or igneous rock Martian meteorites found on Earth, researchers say. Examining the crater and the meteorites also led to new revelations about how old the rocks are.



A look at **Mojave Crater on Mars**. The rays are evidence of debris thrown up from an impact that happened about 5 million years ago. The arrow points towards crater clusters used to estimate the age of the region. Credit: Science/AAA. **Full size image:**

<http://i.space.com/images/i/000/037/440/original/mojave-crater-mars.jpg?1394132480>

"We tried to find good arguments to convince ourselves that [Mojave Crater] was five million years or younger. You don't expect this size of crater so recently formed, statistically at least," lead author Stephanie Werner, a planetary scientist at the University of Oslo in Norway, told Space.com.

A team from the University of Oslo in Norway first used a technique called crater counting, which estimates a region's age by seeing how many large and small craters are in a particular zone. The more large craters, the older the terrain likely is. They found the crater is indeed about five million years old. The material blasted from Mojave Crater had fewer meteorite strikes than the surrounding channel floor.

### Age dispute

Mineral studies of Mojave Crater using NASA's Mars Reconnaissance Orbiter and the European Space Agency's Mars Express orbiter revealed a good match with **shergottites**, as both the meteorites and the crater had pyroxene minerals in similar abundances. Shergottites are named after the Shergotty meteorite, which fell at Sherghati, [India](http://en.wikipedia.org/wiki/Martian_meteorite#Shergottites) in 1865. They are igneous rocks of mafic to ultramafic lithology, [[http://en.wikipedia.org/wiki/Martian\\_meteorite#Shergottites](http://en.wikipedia.org/wiki/Martian_meteorite#Shergottites)]

The find yielded an age mystery. Shergottites (which make up about 75 percent of [Mars meteorites](#) found on Earth) appear to be youngsters despite their origins. While a plateau around Mojave Crater is 4.3 billion years old, shergottites were believed to have crystallized (or solidified) between about 150 million years ago and 600 million years ago. Reconciling this difference was the team's next step.

The study suggests scientists underestimated the shergottites' crystallization age because the rocks were "reset" by melting events such as meteorite impacts, tectonic activity and volcanic eruptions. Once the rock is broken up with heat or geochemical processes, when it is reformed it would appear much younger than it actually is. So the shergottites may be around 4.3 billion years old, a provocative conclusion..

#### Presence of life?

There are channels around Mojave Crater that suggest the presence of water in two different geological episodes, one less than 5 million years ago, the other probably more than 3.3 billion years old. It's unclear whether an impact in the water-rich area would destroy or boost the chances of life on Mars.

The team hopes to enhance dating techniques on Mars by comparing crater counts to mineralogical [data](#) gleaned from orbit, and up-close counts by the Curiosity and Opportunity rovers on the surface.

The researchers plan to look for more source craters for Martian meteorites, and to keep their fingers crossed for a future sample-return mission to return samples to Earth for better analysis. ##

### The 'People's Map of Mars': Name a Red Planet Crater for \$5

<http://www.space.com/24811-mars-crater-name-project-uwingu.html>

<http://www.space.com/16908-space-projects-private-funding-uwingu.html>

**Uwingu will use the money** raised by the project — which could be more than \$10 million, if people name every available Martian crater — **to fund grants in space exploration, research and education**, which is the company's stated chief purpose.

February 26, 2014 – Naming landmarks on Mars isn't just for scientists and rover drivers anymore.

Starting today February 26th, anybody with an Internet connection and a little money to spare can name one of the Red Planet's 500,000 or so unnamed craters, as part of a mapping project run by the space-funding company Uwingu. (Uwingu means "sky" in Swahili) The 5\$ fee goes up with crater size.

Uwingu will use money raised by the project to fund grants in space exploration, research and education, which is the company's stated chief purpose.

If the effort succeeds in naming all of Mars' cataloged craters The company aims to solicit names for other Red Planet features, such as canyons and mountains, in the future.)

The crater-naming project will be on a first-come, first-served basis. Names will be accepted immediately and will remain approved unless Uwingu officials later determine them to be profane or otherwise offensive.

The "new map" is not trying to supplant other Mars maps, such as the one generated by the United States Geological Survey. Rather the 15,000 Red Planet features whose names have already been approved by the International Astronomical Union (IAU) will be grandfathered into Uwingu's base map.

The Uwingu project also will not seek approval from the IAU. Rather, the crater monikers will be informal or popular names, Stern said. (Unofficial names can still come into wide usage: "The Milky Way," for example, is not IAU-sanctioned.)

Uwingu has also raised funding by asking the public to choose monikers for the thousands of exoplanets and exoplanet candidates being discovered around the galaxy, including Alpha Centauri Bb, the closest alien world to Earth.

To learn more about the Mars map project, and to buy a crater name of your own, go to [www.uwingu.com](http://www.uwingu.com). ##

<http://www.pacificspacecenter.com/astronomers-union-says-it-wont-recognize-crowdsourced-mars-crater-names/> - <http://www.thespacereview.com/article/2468/1>

## HUMANS TO MARS

### One-Way Mars Trip: 1,058 Private Martian Colony Volunteers Pass 1st Cut

<http://www.space.com/24112-private-mars-colony-1058-martian-volunteers.html>

December 31, 2013 – Mars One announced Monday (Dec. 30) that it has picked 1,058 aspiring “spaceflyers” to move on to the next round in its search for the first humans to live on the Red Planet.

The Netherlands-based nonprofit wants to start launching groups of four on one-way trips to Mars by 2023, with the long-term goal of creating the first permanent settlement on Mars. More than 200,000 people applied for a spot on Mars One’s list of future colonists by the time the initial application window closed on Aug. 31. The only requirement to apply was to be over age 18.

Those who get to move on to the next, more rigorous selection phase were notified by email.

**More:** <http://www.mars-one.com> – [http://en.wikipedia.org/wiki/Mars\\_One](http://en.wikipedia.org/wiki/Mars_One)  
<http://www.mars-one.com/faq/selection-and-preparation-of-the-astronauts/what-are-the-qualifications-to-apply>

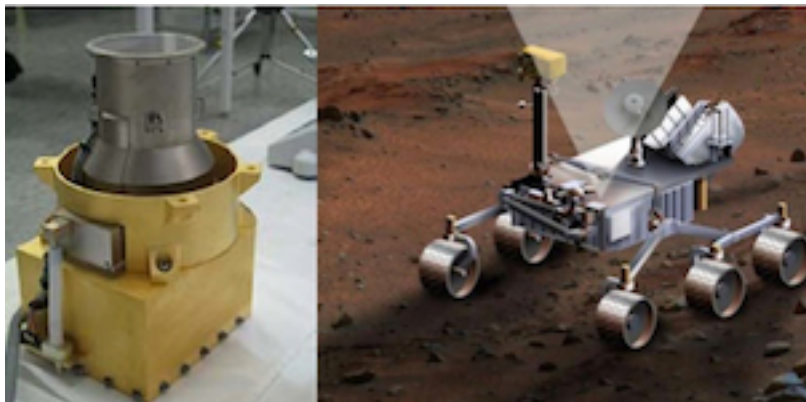
### Calculated Risks: How Radiation Rules Manned Mars Exploration

February 18, 2014 – <http://www.space.com/24731-mars-radiation-curiosity-rover.html>

“Don’t forget to pack your shielding”

**Nearly everything we know about radiation exposure on a trip to Mars we have learned in the past 200 days.** We didn’t how much, or how little Mars itself would protect human visitors until very recently. The first-ever radiation readings from the surface of another planet were published last month in the journal Science. The take-home lesson: **don’t forget to pack your shielding.**

On Earth we’re protected by our magnetosphere and relatively thick atmosphere. But radiation is a daily fact of life on Mars,” said Don Hassler, he lead author on the paper, “Mars’ Surface Radiation Environment Measured with the Mars Science Laboratory’s Curiosity Rover.”



Radiation Assessment Detector (RAD) flight model in the lab (left) and artwork of an older MSL rover design, showing RAD charged particle channel 65° field-of-view pointing towards the zenith.

#### Measuring radiation on Mars

According to the Health Physics Society, the biggest source of radiation for most of us, by far, is inhaled radon. The sky above our heads and the earth beneath our feet are typically the least of our worries. In open space, we must continuously contend with intense solar and cosmic background radiation. Solar energetic particles (SEPs) and galactic cosmic rays (GCRs) which would turn a trip to Mars into a six-month radiation shower. The rover Curiosity has allowed us to finally calculate an average dose over the 180-day journey. It is approximately 300 mSv, the **equivalent of 24 CAT scans.**

**In just getting to Mars, one would be exposed to more than 15 times the annual radiation limit for a worker in a nuclear power plant.**

Data from Curiosity also demonstrated that landing only partially solves the problem. On Mars’ surface, cosmic radiation coming from the far side of the planet is blocked, cutting detected GCRs by half. But the protection from strong solar particles is “shoddy and inconsistent.” Substantial variations in SEPs occur as the meager Martian atmosphere is tussled by solar wind.

“The variability in radiation levels is much larger than expected, and there are also seasonal variations in radiation. These fluxes critical in determining the possibility of life on the Red Planet.

“Radiation is probably the key parameter in determining how much alteration organics are experiencing in the rocks on the surface.



Nearly all we know about radiation exposure on a trip to Mars, we've learned in the past 200 days.

[Apparently the author and some others naively believed that, despite the absence of a Van Allen Belt around Mars, once our explorers safely landed on Mars surface, the planet would provide shielding from the ravages of radiation. We He didn't know how much, or how little, until very recently. - Editor]

The first radiation readings from the surface of another planet are published in the journal Science.

[For the author of this article, "the take-home lesson, as well as "the getting-there lesson" and "the staying-there lesson," is this: don't forget to pack your shielding." Yes, en route. But for those on Mars, the idea of bringing shielding for out habitats is absurd, we can use the soil (regolith) on Mars as shielding, just as we will on the Moon. But, again, just as on the Moon, we will do well to also provide some shielding for vehicles travelling across the surface.]

"Radiation is the one environmental characteristic that we don't have a lot of experience with on Earth because we're protected by our magnetosphere and relatively thick atmosphere. But it's a daily fact of life on Mars." said Don Hassler, lead author on the paper, "Mars' Surface Radiation Environment Measured with the Mars Science Laboratory's Curiosity Rover." [We've known this for some time.]

### Measuring radiation on Mars

Curiosity has allowed us to finally calculate an average dose over the 180-day journey. It is approximately 300 mSv, the equivalent of 24 CAT scans. In just getting to Mars, an [unprotected] explorer would be exposed to more than 15 times an annual radiation limit for a nuclear power plant worker.

Data from Curiosity also demonstrated that landing only partially solves the problem. Once on the Martian surface, cosmic radiation coming from the far side of the planet is blocked. [Again, who couldn't figure that out?] This cuts down detected GCRs by half.

The protection from strong solar particles, though, is shoddy and inconsistent. Substantial variations in SEPs occur as the meager Martian atmosphere is tussled by solar wind. The variability [in radiation levels] was much larger than expected, [This creates] variability in weekly and monthly dosage. There are also seasonal variations in radiation.

Study co-author Jennifer Eigenbrode, from the Goddard Institute of Space Studies, described how fluxes in radiation are critical in determining the possibility of life on the Red Planet. "Radiation is probably the key parameter in determining how much alteration organics are experiencing in the rocks on the surface." This is because the most powerful particles in the air also penetrate the Martian soil. On impacting the surface, the GCRs and strong SEPs from space produce gamma rays and neutrons easily capable of breaking molecular bonds in the soil.

**These events may have obliterated all evidence of life close to the surface. The new study estimates that finding intact organic molecules means digging deeper, down a meter or so, and digging for newer evidence, near impact sites where rock has spent less time exposed to the elements.** "If we find organics on Mars, the circumstance in which we find them [the context of the rocks], the history of the rocks, and the chemistry that we find, will help guide our mission strategy."

Radiation levels measured by Curiosity are a better guide on how and where to look for former or current life. Future life, and the lives of our astronauts, also hinges upon these radiation measurements.

We can design shelters on the surface to protect the astronauts. Deep space, the place of greatest exposure, remains an issue. "Perhaps one of the areas they would be most vulnerable would be during a spacewalk [on the way] to Mars," but space walks are no more than hours long, and crew members tackling a problem that requires going outside the ship can take turns.

### Predicting space weather

In transit and on the planet, surviving space means predicting space weather. Space weathercasting is a relatively new field, but one that's proving to be critical to all space missions. This involves forecasting solar flares, coronal mass ejections, and geomagnetic storms. These highly energetic events emanate from the Sun. When they cross the orbit of a planet, the same SEPs attacking organics can spell disaster for satellites, space stations, astronauts and the communication systems they all depend upon.

Protecting satellites and people around Earth and Mars likely involves setting up two separate systems. Using Earth-based technologies to predict the radiation levels on Mars isn't the best choice. The distance and opposition of the planets compounds the problem. When Mars is on the far side of the sun, it isn't even an option.

"When we send people to Mars, we will have to do our own space weather monitoring from [Mars]," Hassler said. What we've learned from RAD will be used to better look for life on the surface, to **design suits and habitats, and to plan extravehicular activities.**

"We can tell explorers that there is an increased risk of cancer associated with a trip to Mars (approximately 5 percent over a lifetime)." ##

## NASA: 2021 Private Inspiration – Venus/Mars Flyby Mission Needs \$

<http://www.space.com/24860-private-mars-flyby-2021-congress-nasa.html>

March 01, 2014 – A private manned Mars flyby mission in 2021 could be an inspiring precursor to landing astronauts on the Red Planet's surface in the not-too-distant future, but much work needs to be accomplished before that goal can become a reality, experts told Congress Thursday (Feb. 27).

The Inspiration Mars Foundation, led by the world's first space tourist Dennis Tito, aims to launch a pair of adventurous space explorers on a flyby of Mars in just seven years. **That 2021 launch target takes advantage of a rare alignment that would allow the astronauts to fly by both Venus and Mars in a single trip.**

But to meet that **[new]** window, Inspiration Mars needs NASA's help. You can also watch a video of Congress' Mars flyby 2021 hearing [here](#).

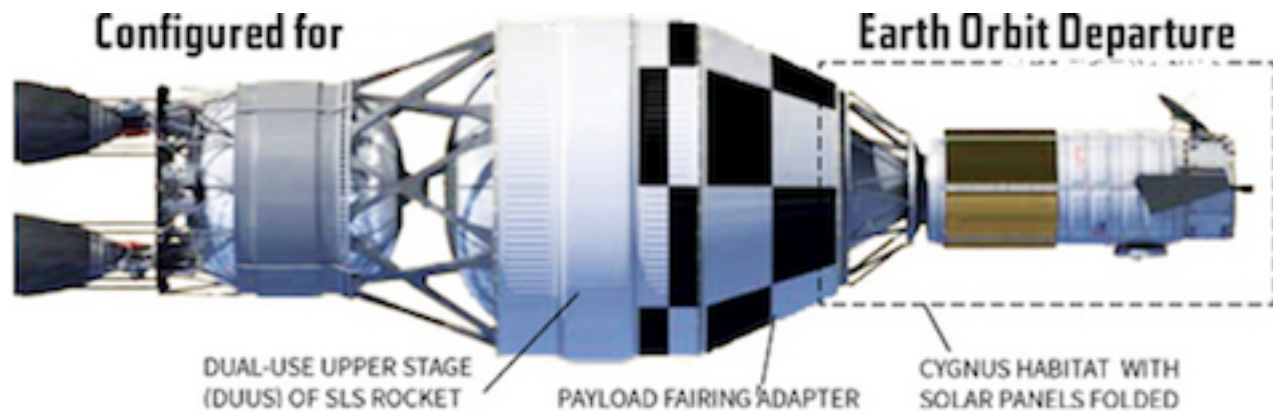
<http://www.space.com/19985-private-mars-mission-flyby-dennis-tito-infographic.html>

<http://www.space.com/19982-private-mars-mission-gallery-inspiration.html>

<http://www.space.com/24856-mars-2021-human-fly-by-public-or-private-congress-questions-video.html>

The private organization hopes NASA will provide one of its giant Space Launch System rockets as well as an Orion deep-space capsule — which are both still in development — to fly the mission.

The U.S. House of Representatives' Committee on Science, Space and Technology held the hearing Thursday, Feb 27, 2014 to discuss how feasible such a Mars flyby in 2021 actually is.



"I continue to believe, as do many Americans, that Mars is the logical destination to put human space exploration back on track and demonstrate the 'can do' spirit that seems to have faded over time," Tito said in a written statement released after the hearing. "The window of opportunity in 2021 is challenging but achievable, and waiting to be claimed."

While a Mars Flyby might be possible in 2021, it will not happen without a clear budget and timeline. NASA needs to set forth its vision for other milestones that will help pave the way for a flyby,

"The Mars flyby can only be discussed in the context of the larger strategy and the associated missions and operational goals. [snip] Any plan, whether its goals are to retrieve an asteroid, establish a lunar base or send people to Mars (or any combination thereof) is doomed to failure without the resources to support it — resources provided in a sustained and sustainable manner based on realistic projections." "Underlying that goal [to reach the Moon] was neither a longer-term strategy nor vision — [snip] but a sprint to the Moon for political purposes. And because of this, the U.S. space program has since suffered."

## Curiosity Rover Takes Aim at Sandstone Variations

[http://www.marsdaily.com/reports/NASA\\_Mars\\_Rovers\\_Next\\_Stop\\_Has\\_Sandstone\\_Variations\\_999.html](http://www.marsdaily.com/reports/NASA_Mars_Rovers_Next_Stop_Has_Sandstone_Variations_999.html)

<http://www.space.com/25207-mars-rover-curiosity-science-target.html>

March 25, 2014 – NASA's Mars rover Curiosity has its next science target in sight. Its position is just 282 feet (86 meters) north of "the Kimberley," where four different types of terrain intersect. Scientists are keen to study the Kimberley rocks and may even break out Curiosity's sample-collecting drill at the site.

Available orbital images don't tell us what those rocks are, but "now that Curiosity is getting closer, we're seeing a preview. The contrasting textures and durabilities of sandstones in this area are fascinating. While superficially similar, the rocks likely formed and evolved quite differently from each other."

The Kimberley sandstones represent a different type of rock for Curiosity to examine. To date, it has primarily scrutinized finer-grained mudstones. Some of those mudstones, at a site called Yellowknife Bay, preserved evidence of an ancient stream-and-lake system, leading mission scientists to announce last year that Mars could have supported microbial life billions of years ago.

Understanding variations in Martian sandstones — some are harder than others — could help piece together parts of the Red Planet's past and explain the large-scale contours of Gale Crater. A major issue is to understand why some rocks resist erosion more than other rocks, especially when they are so close to each other and are both likely to be sandstones.

Curiosity is now en route to the base of Mount Sharp which rises 5.5 km (3.4 mi) into the sky from Gale Crater's center. The plan is for Curiosity to climb up Mount Sharp's foothills, reading a history of Mars' changing environment conditions as it goes.

Curiosity left the Yellowknife Bay area last July. It has stopped occasionally since then to examine rocks, the mission team has mainly prioritized making tracks. The road to Mount Sharp covers more than 8 km (5 mi); Curiosity should get there around the middle of this year.

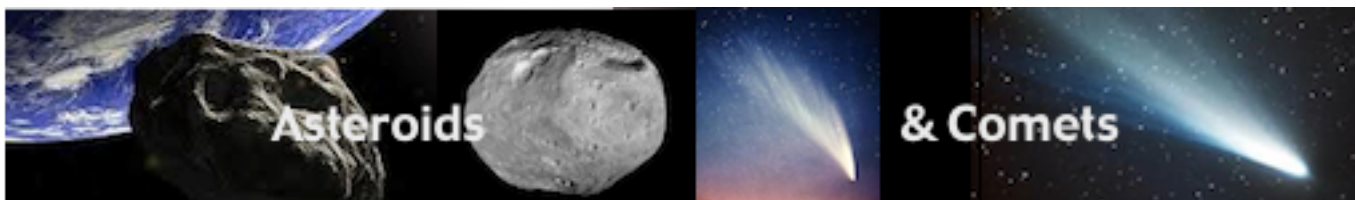
Variations in the stuff that cements grains together in sandstone have shaped the landscape surrounding

Curiosity is now approaching a site called "the Kimberley," a location picked last year as a likely place to pause for investigation. Four types of terrain with different rock textures intersect there.

The rocks that Curiosity mission has studied most intensively so far are finer-grain mudstone, rather than sandstone. The rover found evidence for an ancient lakebed environment favorable for microbial life when it analyzed sample powder drilled from mudstone last year in an area called "Yellowknife Bay."

"Material filling the space between grains of sand in sandstone is called cement, whatever its composition. Cement characteristics can vary greatly, depending on the environmental history that affected the rock. Sandstones with some clay-mineral cements are quite soft. Tap them with a hammer and they crumble. Sandstones with quartz cement can be very hard. Hit them with a hammer and they ring." Variations in cement material of sandstones could provide clues to different types of wet environmental conditions in the area's history.

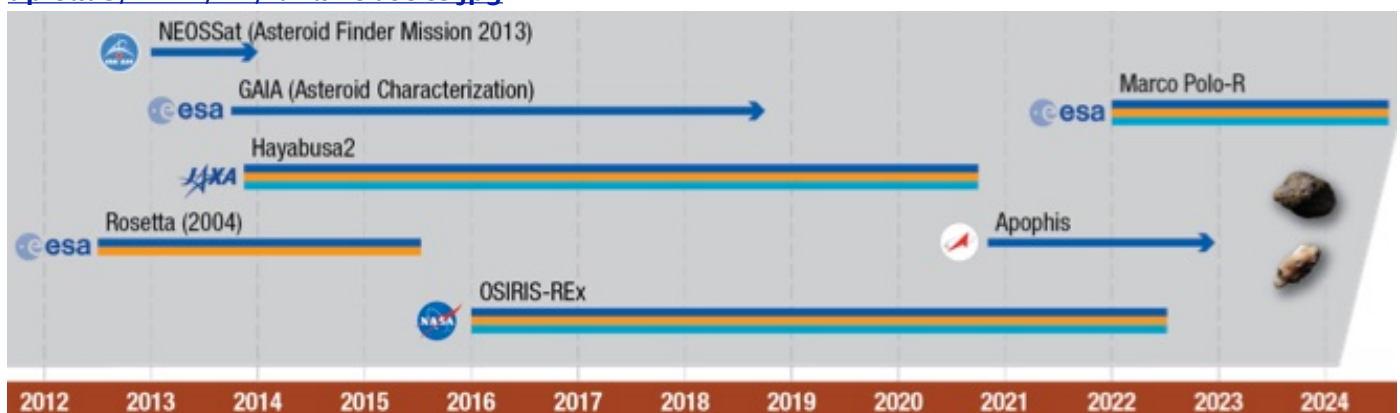
NASA's Mars Science Laboratory Project is using Curiosity to assess ancient habitable environments and major changes in Martian environmental conditions. JPL, a division of the California Institute of Technology in Pasadena, built the rover and manages the project for NASA's Science Mission Directorate in Washington. ##



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

## ASTEROIDS

Asteroid Missions on the horizon - <http://www.globalspaceexploration.org/wordpress/wp-content/uploads/2013/12/lunarrobotics.jpg>



## OSIRIS-REX: "Tag Sampling an Asteroid (VIDEO)

<http://www.space.com/24567-5-second-asteroid-touch-enough-for-sample-return-video.html>

look for still shots

## NASA takes Major Step in hunt for Asteroids

[http://www.spacedaily.com/reports/NASA\\_takes\\_major\\_step\\_in\\_hunt\\_for\\_asteroids\\_999.html](http://www.spacedaily.com/reports/NASA_takes_major_step_in_hunt_for_asteroids_999.html)

Feb 24, 2014 NASA's mission to reel in an asteroid took an important step forward when the agency recently established a new "**rapid response system**" intended to pinpoint the most eligible targets for capture. By setting up this new screening process, NASA hopes to narrow down the list of possible capture targets. The goal is to bring an asteroid into a stable lunar orbit so it would become a suitable landing destination for an astronaut.

### Two goals advanced by one project

NASA believes that the project would also permit scientists to experiment with various methods that could theoretically divert hazardous objects away from the Earth. The first step is both simple and difficult at the same time: **choosing the right asteroid to capture**. This process is particularly hard considering that many asteroids are simply too big to consider moving for a project such as this, while the unstable orbits of other rocks also makes them poor choices.

The ideal asteroid size is somewhere below 12 meters (40 feet) across. But the sheer quantity of space rocks in this category presents a problem. "There are hundreds of millions of objects out there in this size range, but they are small and don't reflect a lot of sunlight, so they can be hard to spot." Under the new screening system, the agency mines a large library of near-Earth objects until it finds a potential candidate. Once a target is found, scientists take to their powerful telescopes in order to gather more data on the rock – a process that needs to be finished quickly, since asteroids typically move out of a telescope's sight within a couple of days.

"If an asteroid looks as if it could meet the criteria of size and orbit, our automated system sends us an email with the subject 'New ARM Candidate,' When that happens, and it has happened several dozen times since we implemented the system in March of 2013, I know we'll have a busy day."

So far, NASA has only been able to identify two targets a year as potential candidates, but the agency is hoping to up that number to four or more. ##

## NASA Sees Targets for Asteroid Capture Mission

February 19, 2014 – <http://www.space.com/24737-nasa-asteroid-capture-mission-targets.html>



This concept image shows an astronaut preparing to take samples from the captured asteroid after it has been relocated to a stable orbit in the Earth-Moon system. Hundreds of rings are affixed to the asteroid capture bag, helping the astronaut carefully navigate the surface. Image: Aug. 22, 2013. NASA

NASA has set up a "rapid response system" to pick the best candidates for its ambitious asteroid-capture mission and aims to use a robotic spacecraft to haul a near-Earth asteroid into a stable lunar orbit, where astronauts would visit it in the future. Many asteroids are too big to be moved easily or are in unstable orbits. Others are too distant for telescopes to figure out what they're made of, which could make them unsuitable candidates.

If size were the only factor, we'd be looking for an asteroid smaller than about 12 m (40 ft) across, Paul There are hundreds of millions of objects out there in this size range. But they are small and



don't reflect a lot of sunlight, so they can be hard to spot" Chodas. The best time to discover them is when they are brightest, and already close to Earth.

NASA is billing the **Asteroid Capture Mission** as one step in that process, arguing that the effort could help test out processes to move a threatening rock out of its Earth-crossing orbit.

To find the best candidates, NASA's new screening process plumbs a database of "small bodies" discovered near Earth. These bodies are typically found by amateur astronomers, who then pass on the information to the Minor Planet Center in Cambridge, Mass. Researchers at JPL use this database to update their own information.

"If an asteroid looks as if it could meet the criteria of size and orbit, our automated system sends us an email with the subject 'New ARM Candidate When that happens, and it has happened several dozen times since we implemented the system in March of 2013, I know we'll have a busy day."

<http://www.space.com/22489-animation-of-proposed-asteroid-redirect-mission-video.html>

NASA must move quickly when a candidat is found, because newly spotted near-Earth objects are usually visible in telescopes for just a few days before they move out of range. If the telescopes are available, NASA uses two massive radar observatories — the Deep Space Network station at Goldstone, Calif., and the Arecibo Observatory in Puerto Rico — to get more details on size and rotation.

Other observatories may be used to chart its path in space. The NASA-funded Infrared Telescope Facility in Mauna Kea, Hawaii, if available, can provide information on the asteroid's composition. Another potential helper is NASA's reactivated NEOWISE spacecraft, whose new mission is to track asteroids that pass close to Earth.

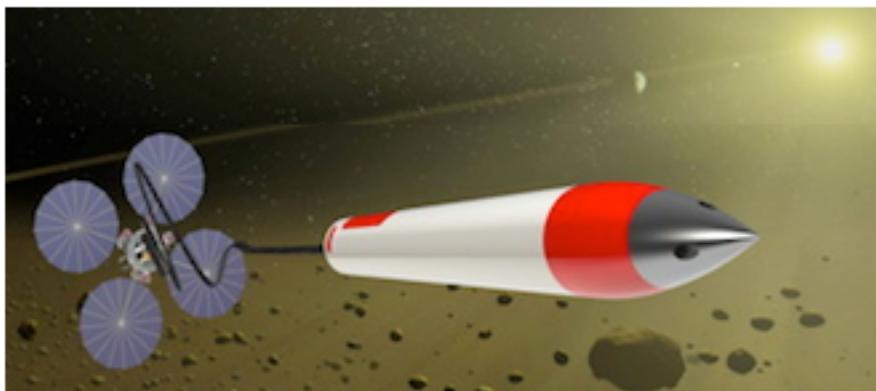
Only about two potential candidates are discovered every year through this process, but at least four might be found if several more "imaging assets" come online, such as an upgrade to the NASA-funded Catalina Sky Survey in Arizona.

NASA currently spends \$20 million a year seeking dangerous space rocks in its Near Earth Observation Program. NASA's 2014 budget request has \$105 million for the asteroid capture and redirection project, some of which will go toward seeking partnerships for the venture. ##

## Space 'Harpoons' Could Snatch Samples of Asteroids and Moons

<http://www.space.com/24779-sample-return-spacecraft-penetrator-tether.html>

<http://www.space.com/24567-5-second-asteroid-touch-enough-for-sample-return-video.html>



artist conception of the penetrator

February 24, 2014 – **Why bother landing softly on an alien world to collect samples if you can just snag material with a harpoon from afar?**

Using a set of long-lined, hard-hitting harpoons would allow a mission to grab large samples from multiple locations on an asteroid or small moonlet — and to get them from beneath the surface, where some of the most interesting material lies, say researchers. Samples of the order of a few kilograms from depths of a few meters, could greatly enhance our knowledge of solar system objects and the resources therein. This offers the opportunity to take multiple samples (from either multiple objects or from multiple areas of a few objects) at little extra cost so that it will provide much greater flexibility and greatly enhance the science return for any given mission.

**A new paradigm for sample-return?**

While robotic spacecraft are getting more and more capable and independent, scientists are still keen to bring extraterrestrial material back to the lab for analysis. There's just no substitute for human expertise, and there's no way to pack all of the instruments in a typical university lab onto a space probe.

The standard way to do a robotic sample-return mission is to perform a soft landing on a celestial object, collect small amounts of material and then blast off toward Earth once again. Japan's Hayabusa probe used this strategy when it chased down the asteroid Itokawa in 2005.

[But] "we're talking about using the kinetic energy of the spacecraft as it's moving past the object, and we're not asking the system to brake, so you save energy and delta v [change in velocity]." The current idea calls for a sample-return craft to carry six lightweight, rocket-shaped "penetrators," which would be swung down at the target object from orbit or during a flyby using a miles-long space tether.

The penetrators would hit at high speed — up to 3,605 km/h (2,240 mph) or 1 km/sec or so — and go deep beneath the surface. During the impact, they would collect several kg of material in a sampling canister, reeled back to the parent probe by the tether for eventual return to Earth. The penetrator's outer shell of the penetrator would remain in the asteroid. This six-shooter approach enables the collection of multiple samples.

"Going to one spot is both expensive and typically will raise more questions than it answers," he said. "There's a lot of cost reduction in doing multiple ones [samples], and the scientific return will be geometric at least, because then you've got several samples from different points, and you can actually see what the homogeneities in the system are."

Potential targets of a "hard landing" sample-return mission range from tiny asteroids up to bodies as large as Europa and Mercury,

### Applications here on Earth

A tether-penetrator system could also be used on Earth to take samples from extreme or hazardous environments, such as the inside of a volcano or ground contaminated ground by a nuclear accident.

The team has received two rounds of NIAC funding in the last two years. Part of the work involves devising and testing energy-absorbing materials that can withstand the tremendous forces a penetrator will experience when it crashes into its target body. Prototypes that were slammed into the ground during field tests in Nevada's Black Rock Desert last year performed well at impact speeds of 450 mph and 900 mph (725 km/h and 1,450 km/h). ##

## NASA Seeks Proposals on Asteroid Redirect Mission Concepts Development

[http://www.nasa.gov/press/2014/march/nasa-seeks-proposals-on-asteroid-redirect-mission-concepts-development/#.Uy13FhbF\\_ww](http://www.nasa.gov/press/2014/march/nasa-seeks-proposals-on-asteroid-redirect-mission-concepts-development/#.Uy13FhbF_ww) <http://www.nasa.gov/asteroidinitiative>

<http://www.space.com/25175-nasa-asteroid-capture-plan-ideas.html>

<http://www.space.com/20601-animation-of-proposed-asteroid-retrieval-mission-video.html>

March 21, 2014 RELEASE 14-083 – In support of NASA's Asteroid Redirect Mission, it is seeking proposals for studies on advanced technology development, for concept studies in **asteroid capture systems, rendezvous sensors, adapting commercial spacecraft for the Asteroid Redirect Mission** and feasibility studies of potential future **partnership opportunities for secondary payloads and the crewed mission**. NASA wants the first manned visit to the redirected asteroid to occur by 2025

Following evaluations of the proposals, NASA will select up to 25 proposals and make total awards up to \$6 million. Contracts would begin and end this year: <http://go.nasa.gov/1jhiPXs>

The Asteroid Redirect Mission has three major elements:

- Target identification;
- A robotic mission to capture and redirect the selected asteroid into a stable orbit beyond the moon;
- A crewed segment in which astronauts in NASA's Orion spacecraft launched on the Space Launch System rocket will rendezvous with the captured asteroid, conduct spacewalks to collect samples from it, and return them to the Earth for analysis. New capabilities and systems tested through the Asteroid Initiative will advance NASA's ultimate goal of sending humans to Mars.

Proposals are due May 5, and winners are expected to be announced on July 1. NASA will select a maximum of 25 submissions and dole out up to \$6 million in total, officials said.

The asteroid-capture mission aims to drag a small asteroid, or a piece of a larger space rock, into a stable orbit around the moon using a robotic spacecraft. The asteroid would then be visited — perhaps multiple times — using NASA's Orion capsule and Space Launch System now in development. ##

More: <http://www.space.com/25178-nasa-asteroid-capture-mission-targets.html>

<http://www.space.com/20606-nasa-asteroid-capture-mission-images.html>

March 24, 2014 – NASA is making progress in finding a suitable asteroid “rock” less than 10 meters (33 ft) in size – to “shrink-wrap” in space, and then drag into a stable orbit around the Moon, where it would be visited by astronauts by 2025. A dozen or so promising targets have been identified.

In the “**asteroid-redirect mission**,” NASA would use a robotic probe to move the targeted space rock into Earth–Moon space. The asteroid would then be visited, perhaps multiple times, by astronauts using NASA's Orion capsule and Space Launch System rocket, not slated to fly crews together until 2021.

This mission will demonstrate “**stepping stone**” technologies that will allow humans to reach Mars and its moonlets and eventually other destinations in deep space.

As to the science goals, study of an actual astrochunk will advance our understanding of the early solar system and help develop asteroid–mining technology and know–how.

#### From concept to reality

NASA is now seeking innovative ideas that could help take the asteroid–capture mission from concept to reality. Up to 25 proposals are expected and a maximum of \$6 million dollars in awards are available., with awards expected to be announced on July 1. A “**basic mission concept**” should be in place by around the end of the year, though some components of the architecture may be “changed, added or refined” thereafter. ##

## A Planetary Defense Policy By Al Globus & NSS Position Paper: Protecting Earth from Cosmic Impacts

<http://space.alglobus.net/papers/PlanetaryDefensePolicy2014.pdf>

[http://www.nss.org/legislative/positions/NSS\\_Position\\_Paper\\_Planetary\\_Defense\\_2014.pdf](http://www.nss.org/legislative/positions/NSS_Position_Paper_Planetary_Defense_2014.pdf)

Related NSS paper: <http://www.nss.org/resources/library/planetarydefense/index.htm>

Both of these papers are “read only “ online PDF files. We were not even able to copy the forward and the conclusions of either. **TTSIQ Readers are encouraged to read both papers online.** ED

#### Related Press Release

#### National Space Society Issues Position on Protecting Earth From Cosmic Impacts

**(Washington, DC, February 17, 2014)** On February 15, 2013, a meteor exploded over the Chelyabinsk region of Russia. The blast damaged over 7,000 buildings and almost 1,500 people suffered injuries requiring treatment. As we observe the anniversary of that event, it is important to understand its significance and specifically what it means for the United States. Millions of objects in space, including asteroids and comets, are in orbits around the Sun that cross Earth's orbit. When they approach Earth, they are referred to as Near–Earth Objects (NEOs).

Some NEOs are large enough to cause significant damage if they impact the Earth. Many such objects have struck Earth in the past, inflicting damage ranging from trivial up to and including global catastrophe. While a future large strike with catastrophic consequences is certain, we do not know whether it will happen in 150 million years or fifteen months.

The National Space Society (NSS) has been a consistent supporter of actions to defend our home planet from such events. In a position paper [link above], the Society focuses attention on the near–term need and the opportunity to significantly improve our ability to detect and track collision threats to the Earth. While recognizing that this is a global problem, the paper focuses on recommended actions for the United States. Additionally, NSS urges all space faring nations to add an amount of at least **one percent of their civilian space budget** for developing defenses against these threats.

NSS believes that the immediate task before us is to find and track NEOs large enough to cause damage on Earth. Current US ground–based searches should continue. **The Large Synoptic Survey Telescope** [ <http://www.lsst.org/lsst/about> ] should be fully funded and encouraged to vigorously pursue NEO detection. The B612 Foundation's **Sentinel Project** [ <https://b612foundation.org/sentinel-mission/> ] **Sentinel Project** and the **JPL NEOCam** infrared space telescope should be fully funded. Now is the time to more seriously address the detection of long period comets. Additional work should be done on NEO characterization and deflection research.

NSS Space Settlement Advocacy Committee chair Al Globus sums up the situation: “We face an existential threat. We can develop the ability to remove it. There is little or no benefit to waiting. Let's do it.” ##

## Herschel Telescope Detects Water on Ceres

January 22, 2014 - <http://www.jpl.nasa.gov/news/news.php?release=2014-020&1>

Scientists using the Herschel space observatory have made the first definitive detection of water vapor on Ceres. Plumes of water vapor might shoot up periodically from Ceres when portions of its icy surface warm slightly. Herschel is a European Space Agency (ESA) mission with important NASA contributions. This find is being taken as proof that Ceres has an icy surface and an atmosphere.

The results come at the right time for NASA's Dawn mission now on its way to Ceres after over a year orbiting Vesta. Dawn will arrive at Ceres in early 2015, and will map Ceres surface geology and chemistry in high resolution, hopefully revealing whatever processes that drive the outgassing activity..



Ceres is roughly 950 km (590 mi) in diameter and was discovered in 1801

Ceres is believed to contain a rocky interior with a thick mantle of ice that, if melted, would amount to more fresh water than is present on all of Earth. The materials making up Ceres likely date from the first few million years of our solar system's existence and accumulated before the planets formed.

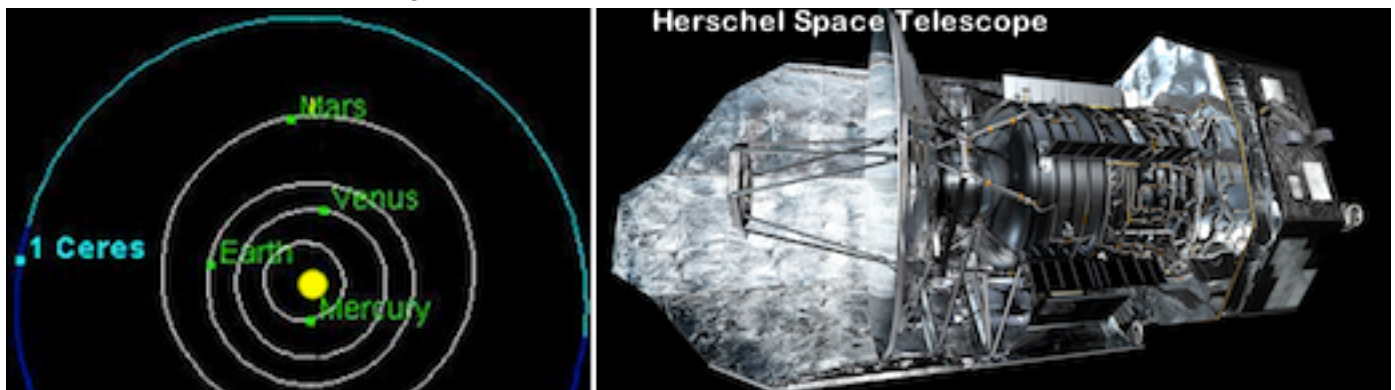
Until now, we believed that ice existed on Ceres but had no direct evidence. It took Herschel's far-infrared vision to see a clear spectral signature of the water vapor four out of five times.

### What scientists think is happening

When Ceres swings through the part of its orbit that is closer to the sun, a portion of its icy surface becomes warm enough to cause water vapor to escape in plumes at a rate of about 6 kg (13 lbs) per second. When Ceres is further from the sun, no water escapes. At its closest (perihelion) Ceres is 382 million km from the Sun. At its furthest (aphelion) Ceres is 445 million km from the Sun.

The strength of the signal also varied over hours, weeks and months, because of the water vapor plumes rotating in and out of Herschel's views as Ceres rotates on its axis. This enabled the scientists to localize the source of water to two darker spots on the surface of Ceres, previously seen by NASA's Hubble Space Telescope and ground-based telescopes. The dark spots might be more likely to outgas because dark material warms faster than light material. When the Dawn spacecraft arrives at Ceres, it will be able to investigate these features, and perhaps identify the darker material as well as mapping this small world.

Herschel is a European Space Agency mission, with science instruments provided by consortia of European institutes and with important participation by NASA. While the observatory stopped making science observations in April 2013, after running out of liquid coolant, as expected, scientists continue to analyze its data. NASA's Herschel Project Office is at JPL, responsible for two of Herschel's three science instruments. The NASA Herschel Science Center, part of the Infrared Processing and Analysis Center at the California Institute of Technology in Pasadena, supports the U.S. astronomical community.



More information about Herschel is online at: <http://www.esa.int/SPECIALS/herschel>.

<http://www.nasa.gov/herschel> - <http://www.nasa.gov/dawn>. ##



## Asteroid Found with Rings! 1st-of-Its-Kind Discovery Stuns Astronomers

<http://www.space.com/25225-asteroid-rings-discovery-video-images.html>

<http://www.space.com/25227-asteroid-chariklo-rings-images-gallery.html>

<http://www.space.com/25177-asteroid-between-saturn-and-uranus-has-rings-animation.html>

[http://en.wikipedia.org/wiki/10199\\_Chariklo](http://en.wikipedia.org/wiki/10199_Chariklo)

March 27, 2014 – Scientists have made a stunning discovery in the outer realm of the solar system. Chariklo, a fairly large asteroid, average 250 km (155 mi) in diameter, has a pair of rings. Chariklo is a “Centaur” – one of an outer astero[d belt between Saturn and Uranus.



Artist's

Conception

Chariklo's rings were most likely formed after a collision scattered debris around the asteroid, according to a new study. The asteroid rings also suggests the presence of a still-undiscovered “shepherd” moon around Chariklo that is keeping them stable.

"We weren't looking for a ring and didn't think small bodies like Chariklo had them at all, so the discovery — and the amazing amount of detail we saw in the system — came as a complete surprise!" study leader Felipe Braga-Ribas, of the National Observatory in Brazil said in a statement today. "This discovery shows that size is not important in order to have — or not have — rings."

On June 3, 2013, Braga-Ribas led a team of astronomers in observing Chariklo as it passed in front of a distant star — a process known as an occultation. As the asteroid traveled, it blocked light from the star, enabling scientists to learn more about it. But they were surprised to discover that a few seconds before and after the main occultation, the light dimmed slightly, indicating that something circled the rocky asteroid. By comparing the data gathered from seven different telescopes, the team was able to identify the shape, size and orientation of the rings. The system consists of a dense, 4 mi-wide (7 km) ring near the asteroid, and a smaller 2-mile-wide (3 km) ring farther out.

From the surface of the asteroid, "they would be two spectacular sharp and really bright rings, crossing all the sky," Braga-Ribas said. "They would be noticeably close, as they are at about 1/1,000 of the moon's distance from us," he added.

The larger, inner ring would block the view of the outer ring from the ground. The rings are possibly formed by rock and water ice, as are Saturn's. ##

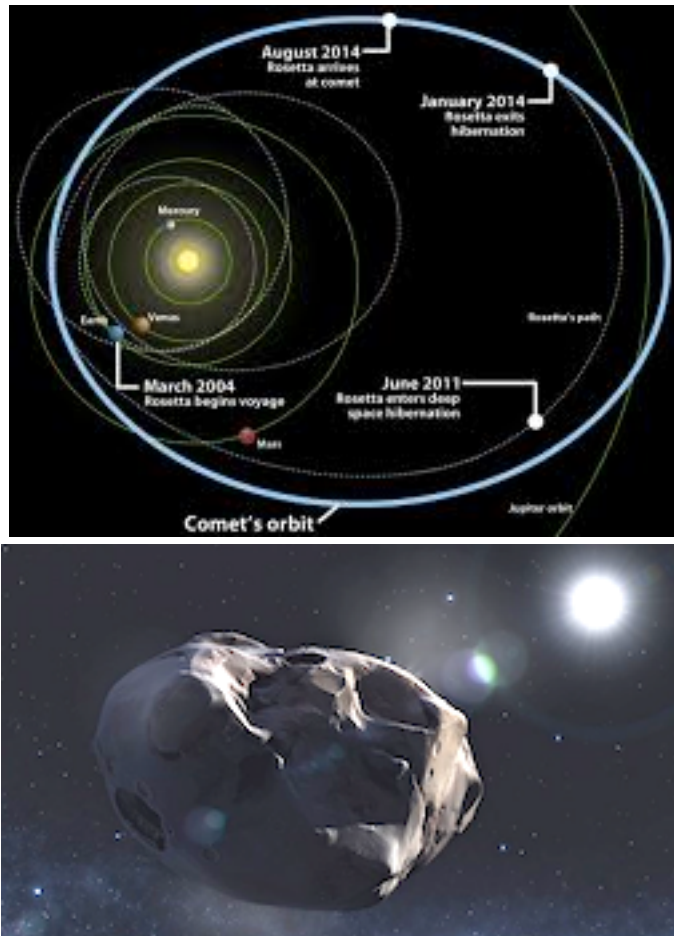
## COMETS

### Rosetta Spacecraft Wakes Up for Historic Comet Rendezvous and Landing

<http://www.space.com/24331-rosetta-comet-spacecraft-hibernation-wakeup.html>

January 20, 2014 – The European comet probe “Rosetta” successfully woke up on schedule, sending a vigorous “yawn” to waiting controllers in Darmstadt, Germany, after a long 2 and a half year sleep.





Artist's

concept

While “asleep” the craft travelled nearly 673 million km (418 million mi.) The wakeup call took hours as Rosetta switched on heaters to warm itself after its long night in the cold of space that far out from the Sun.

The first from the craft was received by NASA's **Deep** Space Network and relayed to ESA's Space Operations Center in Darmstad. After 18 minutes of tense silence the first message home, via Twitter, was "Hello, world!"

The solar-powered spacecraft had slept since mid-2011, when it sailed out near the orbit of Jupiter where there was not enough sunlight to power its systems. Monday's wakeup success sets the stage for what promises to be a historic spaceflight event, the first ever landing on a comet, **67P/Churyumov-Gerasimenko**. It is about 3.9 km (2.4-mi) wide.

First, the solar-powered spacecraft continue warming up and “stretching its limbs.” It will enter orbit around the icy body in August. From orbit, Rosetta will start scouting out potential places on the comet's surface to deliver a 100 kg (220-lb) lander named **Philae**.

A final site is expected to be chosen in October, and the touchdown will follow a month later. If all goes well, Rosetta will release a piggyback probe to land on the comet in November. The probe will spend about a year exploring the comet. The lander has some 10 science instruments, and will use a drill to snag samples up to 20 cm c. (8 inches) beneath the comet's surface.

<http://en.wikipedia.org/wiki/67P/Churyumov-Gerasimenko>

[http://en.wikipedia.org/wiki/Rosetta\\_\(spacecraft\)](http://en.wikipedia.org/wiki/Rosetta_(spacecraft))

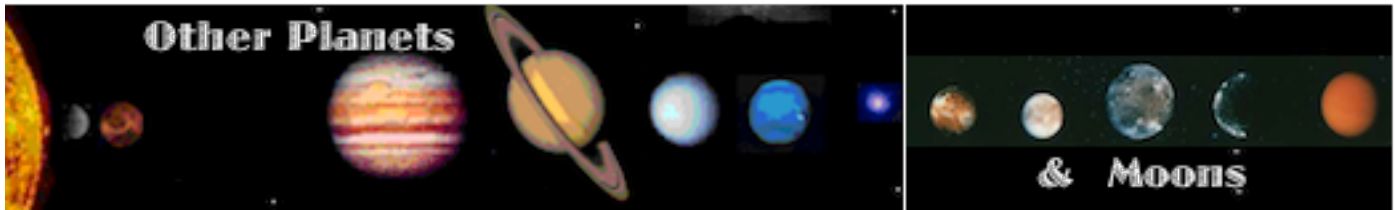
[http://www.open.ac.uk/personalpages/a.j.ball/publications/online/images/rosetta\\_cnsr.gif](http://www.open.ac.uk/personalpages/a.j.ball/publications/online/images/rosetta_cnsr.gif)

### Previous Comet Missions

[http://en.wikipedia.org/wiki/List\\_of\\_missions\\_to\\_comets](http://en.wikipedia.org/wiki/List_of_missions_to_comets)

To date there have been 10 successful “flybys” and a few failures.

This mission will be the first attempt to land on a comet, and thus by far, the most challenging and potentially rewarding comet mission ever attempted. If all the scientific equipment aboard works without a hitch, the results should be exciting as well as very enlightening. ##



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

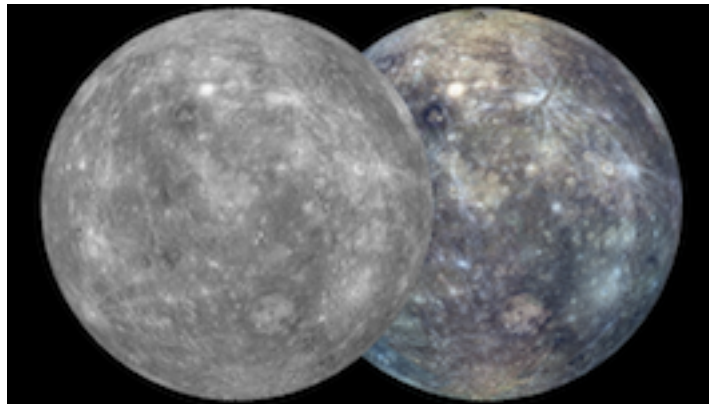
## MERCURY

### Messenger Snaps More than 200,000 Photos of Mercury

<http://www.space.com/24605-mercury-photos-nasa-messenger-200000-images.html>

February 07, 2014 – NASA's Messenger spacecraft has been in orbit around Mercury since 2011. Originally, scientists only expected the probe to beam home 1,000 or 2,000 images of Mercury during the life of its mission, but the spacecraft surpassed that goal long ago.

Johns Hopkins University Applied Physics Lab's Nancy Chabot, instrument scientist for the Mercury Dual Imaging System on MESSENGER, said. "I'm really excited about the many thousands of images that are still in MESSENGER's future, especially those that we plan to acquire at low altitudes and will provide the highest resolution views yet of Mercury's surface."



Messenger Scientists created a four-image mosaic of a piece of Mercury's surface to commemorate the new milestone. The image reveals hollows that might have formed in part of the wall of the 15 km (9 mi) crater in the photo.

The probe is now in its second extended mission, flying closer to the surface of the planet than ever before, allowing researchers to get up-close views of Mercury with more precision than ever before. The mission that has literally revealed an entirely new world to humanity.

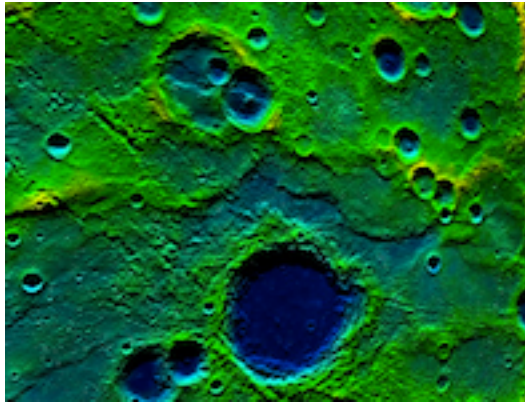
The \$446 million **MESSENGER** mission (short for **M**ercury **S**urface, **S**pace **E**nvironment, **G**eochemistry, and **R**anging) launched to space in 2004. MESSENGER is the first spacecraft ever to orbit the innermost planet in the solar system, and is responsible for creating the first complete map of Mercury's surface. [ <http://www.space.com/20086-mercury-map-nasa-messenger.html> ] It is now in its second extended mission, set to last until 2015. ##

### Mercury's Contraction Much Greater Than Thought

<http://www.astrobio.net/pressrelease/6078/mercury>

March 25, 2014 – New global imaging and topographic data from the MESSENGER orbiter show that the innermost planet has contracted far more than previous estimates, based on a global study of more than 5,900 geological landforms, such as curving cliff-like scarps and wrinkle ridges, that have resulted from the planet's contraction as Mercury cooled. The findings are key to understanding the planet's thermal, tectonic, and volcanic history, and the structure of its unusually large metallic core.

Unlike [Earth](#), with its numerous tectonic plates, Mercury has a single rigid, top rocky layer. Old estimates, based on previous non-global coverage, suggested that the planet had contracted radially by about 0.8 to 3 km (½ to 2 miles) substantially less than that indicated by models of the planet's thermal history.



This image shows a long collection of ridges and scarps on the planet Mercury called a fold-and-thrust belt. The belt stretches over 336 miles (540 kilometers). The colors correspond to elevation—yellow-green is high and blue is low.

Full size color image: [www.astrobio.net/images/galleryimages\\_images/Gallery\\_Image\\_11572.preview.jpg](http://www.astrobio.net/images/galleryimages_images/Gallery_Image_11572.preview.jpg)

The new results, based on the first comprehensive survey of the planet's surface, show that Mercury contracted radially by as much as 4.4 miles (7 kilometers)—substantially more than the old estimates, but in agreement with the thermal models. Mercury's modern radius is 1,516 miles (2,440 kilometers).

Using two complementary techniques to estimate the contraction from their global survey of structures, Byrne and his coauthors identified a much greater number and variety of geological structures on the planet than had been recognized in previous research. They identified 5,934 ridges and scarps attributed to global contraction, ranging from 9–900 km (5–560 mi) in length. The discrepancy between theory and observation, a major puzzle for four decades, has finally been resolved.

## VENUS

### Inflatable Aircraft Could Cruise Venus Skies

<http://www.space.com/24847-venus-exploration-vamp-inflatable-aircraft.html>

March 03, 2014 – A big robotic airship could ply the skies of Venus for up to a year, giving scientists an unprecedented on-the-scene look at Earth's "evil twin." Prior to the first Venus probe launched by the Soviet Union in 1961, science fiction aficionados viewed Venus as a hot desert world, or a steaming hot jungle world. But in reality, Venus' climate is more like popular views of hell.

For the past year, engineers at aerospace firms Northrop Grumman and L'Garde have been working on an unmanned concept vehicle called the **Venus Atmospheric Maneuverable Platform**. Using a mixture of powered flight and passive floating, **VAMP** could stay aloft for long periods, collecting a variety of data about Venus and its atmosphere.



Northrop-Grumman Artist's concept of an inflatable airship cruising through the skies of Saturn's huge moon Titan. Aerospace firms Northrop Grumman and L'Garde have been developing a Venus-specific version of this vehicle called VAMP (short for Venus Atmospheric Maneuverable Platform).

No big breakthroughs are required to get VAMP — now in the design phase. Northrop Grumman's Kristen Griffin told SPACE.com in December "It really is something that could be developed when the [scientific] community is ready for it."



## A Venus airship

VAMP is a big but incredibly light inflatable aircraft. While its 46 m (151 ft) wingspan dwarfs that of NASA's now-retired Space Shuttle, the triangular VAMP would tip the scales at just 450 kg (990 lbs).

### Mission architecture:

After hitching a ride to Venus orbit with a carrier spacecraft, VAMP deploys and inflates (with hydrogen or another buoyant gas) while still linked to this mothership. VAMP detaches and spirals down toward the planet, entering Venus' thick hot atmosphere in a slow, smooth entry that needs only minimal thermal-protection gear.

**VAMP would cruise through Venus' skies at altitudes ranging between 55–70 k (34–43 mi), using propellers to get high up during the day, floating passively at lower altitudes after sunset.**

Solar panels would power the craft's propellers, while night-time operations would be supported by batteries or an advanced stirling radioisotope generator (ASRG), converting heat produced by radioactive decay of plutonium-238 into electricity.

The airship could carry up to 20 kg (44 lbs) of scientific gear if scientists wanted it to fly as high as 69 k (43 mi). But a minute sacrifice in maximum altitude — just a mile or so — would allow VAMP to tote a 200 kg (440-lb) payload. Data gathered by the vehicle's onboard instruments would be relayed back to Earth via the carrier spacecraft, in orbit above Venus.

Venus' strong winds would sweep VAMP around the planet every 6 days or so. It could conceivably keep studying Venus for a year before the gradual loss of its buoyant gas brought its mission to an end. (The lead-melting temperatures at Venus' surface make long-term rover and lander missions difficult, but conditions high in the atmosphere are much more benign.)

### Fly the otherworldly skies

Many scientists are eager to learn more about Venus' atmosphere, as that could help them understand how the planet changed from a potentially life-supporting world billions of years ago to the scorching hothouse it is today.

VAMP could help unravel some of Venus' most perplexing mysteries. No cost estimate was given. VAMP-like airships could also find broader application, exploring other worlds as well, such as the gas giants, Jupiter, Saturn, Uranus, and Neptune, as well as Saturn's exotic moon, Titan.

<http://www.space.com/18527-venus-atmosphere.html>

<http://www.space.com/15988-venus-planet-weird-facts.html>

**Editor:** This is not a new concept. We explored this possibility in **Moon Miners' Manifesto #60** November 1992, over 21 years ago. In that paper, "**Rehabilitating VENUS as a Human Destination**", we were looking more at much larger vehicles capable of supporting human crews. Our proposed craft would let out unmanned probes on long tethers carrying information and instructions that would skim over the surface below the thick opaque clouds to visually map the surface below.

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

This paper goes way beyond scientific observation of Venus, and explores ambitious possibilities of one day making it another human world. ##

## Active Volcanoe Revealed on Venus

March 18, 2014 – <http://www.space.com/25106-venus-volcanoes-active.html>



Artist's impression of an active volcano on Venus. Credit: ESA/AOES

Full image: <http://i.space.com/images/i/000/024/266/original/active-volcano-venus.jpg?1354834065>

Scientists have long suspected that volcanoes played a huge role in the evolution of cloud-shrouded Venus, the second planet from the sun. Now, images from Europe's **Venus Express** orbiter are showing that volcanic eruptions may have continued into the present. The evidence: four transient bright spots in a relatively young rift zone known as Ganiki Chasma, observed 36 times by the spacecraft's Venus Monitoring Camera.

Planetary scientist Eugene Shalygin, with the Max-Planck Institute for Solar System Research in Germany, and colleagues constructed mosaics from images taken during the orbital passes and computed the relative surface brightness. They found four transient flashes, estimated to be between 527° and 827° C (980° and 1,520 ° F) - well above the planet's normal 430° C (800 °F) surface temperature.

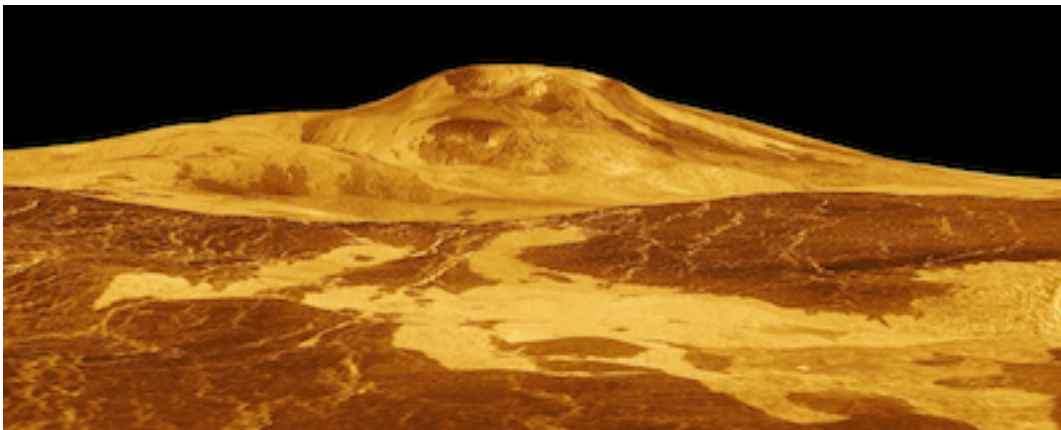
### Metallic "Snows"

The team had been on the lookout for such flashes for years before finding some in four places, all near **Maat Mons**, a giant shield volcano (like Mauna Loa and Mauna Kea on Hawaii Island) that scientists believe last erupted 10 million to 20 million years ago, relatively "yesterday."

Follow-up analysis suggests the bright flashes could be lava flows stretching 26 km (16 mi) or so, a chain of cinder cones, or a volcanic hotspot similar to what has been found on Jupiter's volcanically active moon Io. The plan is comb through archived radar images of Venus made with NASA's Magellan spacecraft between 1990 and 1994 to see if they can find any other evidence of potential volcanic activity, while continuing to use the eight-year-old Venus Express spacecraft to look for flashes in other rift zones.

The discovery of present-day volcanic activity on Venus has "major implications" for understanding processes in the planet's interior, surface and atmosphere.

Also: <http://www.space.com/18807-venus-volcanoes-sulfur-dioxide.html>



[http://en.wikipedia.org/wiki/File:Maat\\_Mons\\_on\\_Venus.jpg](http://en.wikipedia.org/wiki/File:Maat_Mons_on_Venus.jpg)

[http://en.wikipedia.org/wiki/Maat\\_Mons](http://en.wikipedia.org/wiki/Maat_Mons) "Maat Mons is a massive shield volcano. It is the second-highest mountain, and the highest volcano, on the [planet Venus](#). It rises 8 km (5.0 mi) above the mean planetary radius (just north of the equator) at 0.5°N 194.6°E, and nearly 5 km (3 mi) above the surrounding plains. It is named after the Egyptian goddess of truth and justice, [Ma'at](#). ##

## JUPITER

### JUPITER'S MOONS – GANYMEDE

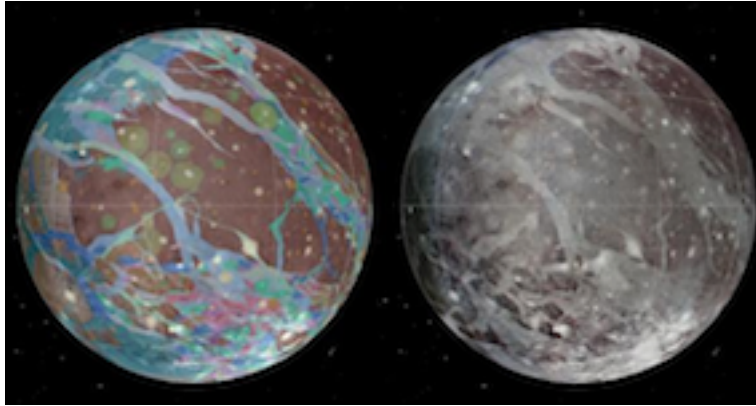
#### First Map of Jupiter's Giant Moon Ganymede Unveiled

<http://www.space.com/24679-jupiter-moon-ganymede-map-photos-video.html>

[http://www.spacedaily.com/reports/A\\_global\\_map\\_of\\_Jupiters\\_biggest\\_moon\\_999.html](http://www.spacedaily.com/reports/A_global_map_of_Jupiters_biggest_moon_999.html)

<http://www.space.com/17824-ganymede-jupiters-largest-moon-video.html>

Feb 13, 2014 –The new map, [of just one hemisphere] published by the U.S. Geological Survey (USGS), could also help scientists plan out the search for alien life;



To present the best information in a single view of Ganymede, a global image mosaic was assembled, incorporating the best available imagery from NASA's Voyager 1 and 2 spacecraft and NASA's Galileo spacecraft. This image shows Ganymede centered at 200 west longitude. This mosaic (right) served as the base map for the geologic map of Ganymede (left).

Full image: [www.space.com/images/i/000/036/889/original/ganymede-map.jpg?1392246285](http://www.space.com/images/i/000/036/889/original/ganymede-map.jpg?1392246285)

After Mars, the interiors of **Ganymede**, **Callisto**, and **Europa** are considered the best candidates for habitable environments for life in our solar system. "This geologic map will be the basis for many decisions by NASA and partners regarding future U.S. missions under consideration to explore these worlds."

Observations of Ganymede made since its discovery in 1610 have revealed many features and facts about Ganymede show that the 5,268 km (3,273 mi)-wide moon possesses dark, heavily cratered terrain as well as lighter, younger regions marked by many grooves and ridges. Its features have been shaped during three major geologic periods — one dominated by impact cratering, then another marked by lots of tectonic activity and finally a third in which this activity tapered off.

The detailed, colorful map confirms some hypotheses regarding Ganymede's geologic history, and disproved others. The more detailed Galileo images showed that cryovolcanism, or the creation of volcanoes that erupt water and ice, is very rare on Ganymede. ##

## JUPITER'S MOONS – EUROPA

### NASA Eyes Ambitious Mission to Jupiter's Icy Moon Europa by 2025

March 6, 2014 – <http://www.space.com/24926-nasa-europa-mission-2015-budget.html>

NASA hopes to launch a mission to the Jupiter moon Europa, perhaps the solar system's best bet to host alien life, a decade or so from now, officials announced Tuesday (March 4). The White House's 2015 federal budget request, released March 4th, allocates \$15 million to help develop a mission to Europa, which harbors a potentially life-supporting ocean of liquid water beneath its icy shell.

The \$15 million is a tiny fraction of the \$17.5 billion allocated to the space agency in the 2015 request — would fund very early "pre-formulation" work for a potential Europa mission. It is not possible at this time to estimate the total size of such a mission. NASA officials will reach out to the scientific community to help map out the mission.

This proposal marks the first time Europa was included in a federal budget request, NASA has received funding to study a possible mission to the 3,100 k (1,900-mi-wide) moon in the past. The best candidate to get off the ground in 2025 or so may be a concept called the "**Europa Clipper**," a concept under development for years. **The probe would orbit Jupiter but make dozens of flybys of Europa, using a variety of science instruments to study the moon's ice shell and subsurface ocean.**

The Europa Clipper could conceivably cruise through the plumes of water vapor erupting from the moon's south pole — intriguing features that were discovered late last year and have helped build momentum for a Europa mission, since they offer a possible way to sample the ocean from afar.

It would probably cost about \$2 billion to get the Europa Clipper off the ground, a pretty high price tag in these tough fiscal times, so some rethinking may be required to take the Clipper — or something like it — from concept to reality.

The Europa Clipper "is what we would call a flagship, and right now the budget horizon is such that we're deferring that kind of mission until later in the decade," Jim Green, head of NASA's planetary science division, said in December at the annual fall meeting of the American Geophysical Union in San Francisco.

Editor's Comments: the abundant cracks in Europa's ice crust almost certainly composed of water from the ocean below freshly frozen. If there is life in Europa's ocean, even microbial life, we should find it on the surface in the cracks. If there is no evidence of microbial life there, then it would seem pointless to drill through the ice into the ocean below. But if we do find frozen microbial life on the surface, there could be more advanced and larger life forms below. In that case, drilling down through the ice crust will have the highest of priorities. ##

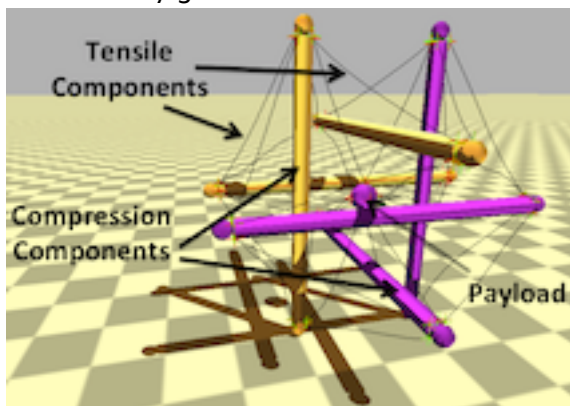
## SATURN

### SATURN'S MOONS - TITAN

#### 'Super Ball Bot' Could Explore Saturn's Huge Moon Titan

<http://www.space.com/24359-titan-superball-exploration-technology.html>

**Jan 21** A baby's toy, of all things, has sparked a new spacecraft design concept that could be used to explore the murky surface of Titan. A few years ago, Adrian Agogino and Vytas Sunspiral, who both work in the Intelligent Systems Division at NASA Ames Research Center, had been batting around a "tensegrity" in the office when they got the idea.



**Left:** A basic diagram of the SuperBall structure



**Right:** A first prototype, called ReCTeR.

Also shown at right is the first rod of a new, larger, prototype able to roll robustly.

Similar to a bicycle wheel, but with more corners to it, a tensegrity shape has a system of wires and cables that deform when pressed, then spring back when the pressure is released. This makes it perfect for small children to bash the toys against their head, other people or the floor without causing damage. While the two were playing with it, the toy fell to the ground, sparking the question: **Why not use that design to land on Titan, which features lakes and seas of liquid methane and ethane?**

Mars type Rovers would not fare well in Titan's marshy environment. A rover geared for Titan would be a design challenge because the moon's shorelines are poorly understood. Titan has lake shores, mud, rain, and terrain that is uneven, and poorly known. That could make its surface dangerous for rovers of more conventional design. A rover can get stuck in muck, or fall over a hill. We don't have good knowledge of the terrain from space observations.

The team's "Super Ball Bot" tensegrity shape recently received \$500,000 Phase 2 funding from the NASA Innovative Advanced Concepts program. In the next two years, researchers hope to nail down the right size and shape for their spacecraft to explore Titan and seek any surface signs of habitability.

#### Titan's pull

Titan has fascinated astrobiologists for decades. Images from Voyager 1 and 2 in 1980 and 1981 showed an orange-colored moon completely covered in clouds, sparking questions about what lay beneath. [<http://www.space.com/11944-nasa-photos-voyager-spacecraft-grand-tour.html>]

We have since learned that Titan's atmosphere has organic aerosols, "tholins", that may have formed from methane and nitrogen molecules.

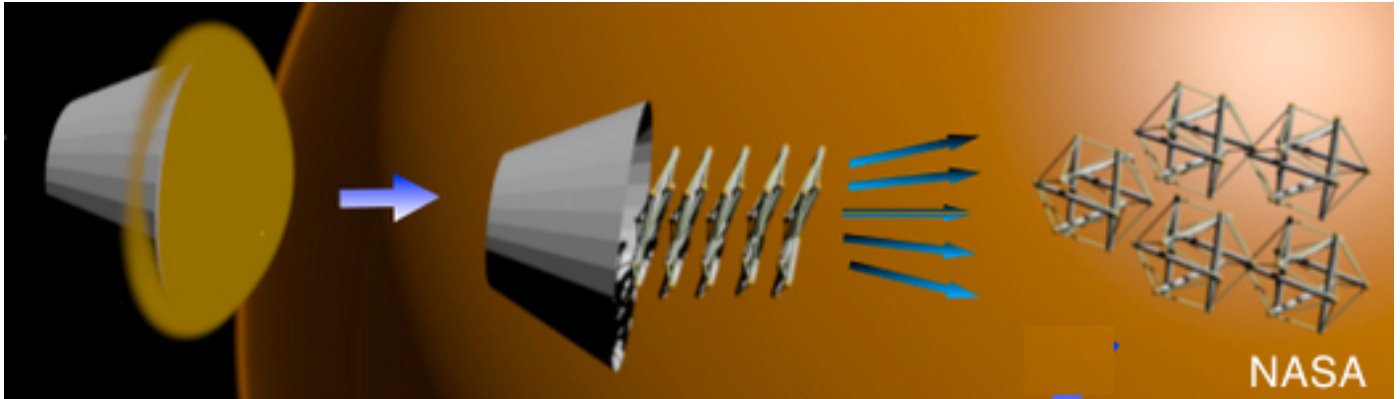
Cassini arrived at Saturn carrying ESA's Huygens lander that landed on Titan's surface January 14, 2005. Later measurements showed that Huygens likely broke through a hard crust, sinking into softer material below, not be a friendly environment for a rover.

A **tensegrity shape** would be perfect match for those conditions. The cables and rods within the structure can flex and move to meet the nature of the ground below.



It can mash itself into a small area, like between rocks, and then get itself unstuck again. Moreover, in the soupy area beside a lakeshore, the Super Ball Bot could roll itself right up to the liquid without the fear of sinking into the ground. "It operates the same way that animals do, muscles expand and contract, the same principle, but more elegant."

Landing would be a cinch with a tensegrity instead of parachutes and landing gear, the robot could be tossed out from a spacecraft several miles up and make it to the surface safely. The trick is to ensure that any instruments on board also survive the shock.



### Early days

Several instrument packages have been selected, and the researchers are now searching scientific literature for more lightweight versions of these instruments, in three packages:

1. **Chemistry** package: gas chromatographs and mass spectrometers to sample lakeshore environments;
2. **Atmospheric** package to gather meteorological data (temperature, wind speed and methane content)
3. **Navigation** cameras and microscopes.

These instruments would "live" (be suspended) in the center of the Super Ball Bot, allowing it to roll around on the surface without destroying these precious payloads. Should one of the instruments need to take a sample, the bot's structure allows it to collapse on the spot — into a triangle shape — and press the sensor on the ground.

No post-Cassini mission to Saturn is yet in the works, but having this novel instrument package ready to go with the capacity to learn much more on this intriguingly different world, Titan, is likely to prod scientists to come up with new mission proposals. In the meantime, this prototype of a mission that offers "revolutionary return" should get agencies thinking.

"The goal over the next two years is to continue to explore the technology and do the prototypes and the demonstrations to find out where the benefits and the challenges are." ##

## A Fast Human Sprinter might just be able to fly on Titan: Here's How

<http://www.space.com/24910-usain-bolt-could-fly-on-moon-titan.html>

March 4, 2014 – Humans would be able to take flight off the surface of Saturn's moon Titan simply by running in a wingsuit — but only if they were as fast as sprinter Usain Bolt, according to a group of physics student say.



Flyer in a "wingsuit" here on Earth – Similar to a the "suit" flying squirrels are born with!

Of all the planets and moons in our solar system, Titan most closely resembles Earth, with stable liquid on its surface and a dense, nitrogen-rich atmosphere. But its lakes are made of methane, it maintains chilly temperatures of minus  $-178\text{ C}^{\circ}$  ( $-288\text{ F}^{\circ}$ ), and the planet has lower gravity and a stronger surface pressure compared with Earth.

Hannah Lerman, a 21-year-old student at the University of Leicester in the United Kingdom, said that she had seen a lot of claims online that humans might be able to get aloft above Titan if only they could run across the alien terrain with wings strapped onto their arms. She wanted to put this idea to the test. She and two classmates factored in the density of air at the surface of Titan, gravity, and the ratio of the path of the air above the wing to that below the wing. The students calculated that a person would need to run at a speed of 11 m/s (36 ft/s) if they wanted to take flight wearing a normal-sized wingsuit with an area of about 1.4 sq m (15 sq ft), just under the human record of Jamaican sprinter Usain Bolt, the fastest man on Earth, whose top speed is slightly higher, 12 m/s (just over 40 ft./s)

“To lift off by running at a more manageable speed of about 6 m/s (20 ft/s), a person would need to wear a more unwieldy wingsuit with a surface area more than three times larger than the normal size, the students said.” ##

## Space Telescope rules out a distant Planet X, or “Nemesis” – or does it?

March 7, 2014 – <http://www.space.com/24989-planet-x-search-nasa-telescope.html>

After scanning the entire sky, throughout 2010 and in early 2011, with a 6-month gap between the two observations, the Wide-Field Infrared Survey Explorer (WISE) found no signs of an undiscovered large gas giant planet or dim and distant companion star in the outer reaches of the solar system. The probe did, however, find several thousand new objects much farther out.

WISE imaged nearly 750 million stars, asteroids, and galaxies, some of which had never been spotted before. Of the 762 new objects in the data, there were no signs of a Saturn-sized object out to 10,000 times the Earth-sun distance. A second study discovered 3,525 new stars and brown dwarfs. But the survey did find Sun-bound objects previously overlooked. Some of these include extremely close stars. A study that looked at WISE data last year found a pair of brown dwarfs just 6.5 light-years from Earth, making it the closest star system discovered in the past hundred years.

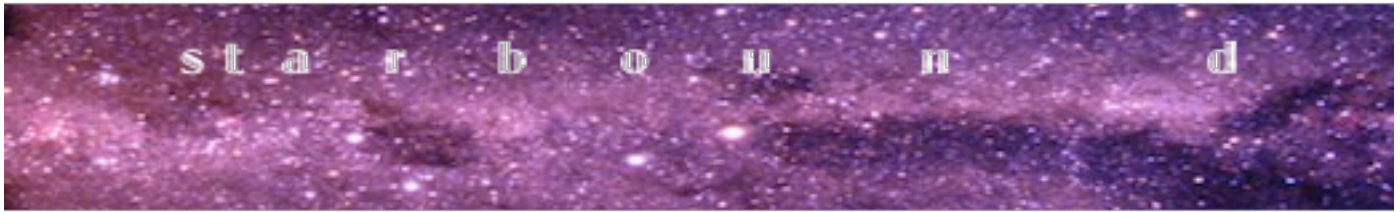
Planets (Greek for “wanderers”) in the inner solar system were easily spotted by early astronomers as they moved across the sky. More distant planets had to wait until the improvement of telescopes for their discovery; Uranus was discovered in 1781 and it took almost another 60 years to locate Neptune.

At the turn of the 20th century, astronomers such as Percival Lowell continued to search for an even more-distant gas planet that could be responsible for disrupting the orbits of Uranus and Neptune. Pluto discovered in 1930, was too small to be the cause. Then, in 1983, it was suggested that a dim companion star to the sun would explain the periodic occurrence of mass extinctions on Earth. A massive body could theoretically disturb objects in the Oort Cloud surrounding the solar system, But the massive body did not turn up in the data from WISE, which scans the heavens in infrared rather than visual light. Since both new studies turned up relatively distant brown dwarfs, they should have had an easier time spotting a companion close enough to the sun to disturb the Oort Cloud, but neither did. #

**But wait a minute!** [www.space.com/25234-planet-x-search-solar-system.html](http://www.space.com/25234-planet-x-search-solar-system.html) – March 27, 2014

The orbits of the newfound object, known as 2012VP113, and some of its neighbors are consistent with (though by no means proof of) the existence of a planet-size “perturber” far from the sun — perhaps so distant that it cannot be detected with current instruments.

<http://www.space.com/25228-dwarf-planets-outer-solar-system-infographic.html>



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

## FUNDAMENTAL PHYSICS: NEW DISCUSSIONS ABOUT BLACK HOLES

<http://www.space.com/24418-stephen-hawking-no-black-holes.html>

Editor: We won't even consider summarizing this discussion!

## OUR STAR: THE SUN

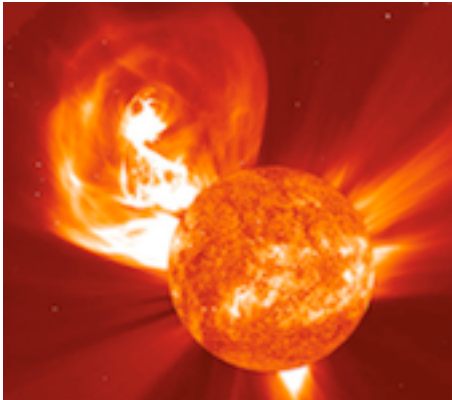
### Sun's Current Solar Activity Cycle Is Weakest in a Century

December 11, 2013 - <http://www.space.com/23934-weak-solar-cycle-space-weather.html>

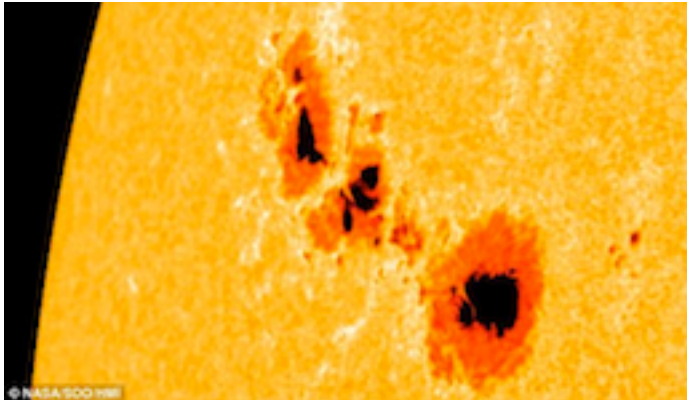
<http://www.space.com/11506-space-weather-sunspots-solar-flares-coronal-mass-ejections.html>

The Sun's current space-weather cycle is "the most anemic in 100 years." "Our star" is now at solar maximum, the peak phase of its 11-year activity cycle. But this solar max is weak, and the overall current Solar Cycle 24, which began in early 2008, is the weakest since the feeble Cycle 14 in the early 1900s.

As no one now alive has ever seen such a weak cycle, we are learning something. Scientists think they know why the solar storms that have erupted during this cycle have caused relatively few problems here on Earth. While CMEs, Coronal Mass Ejections, are no less frequent, those during this cycle have not caused as much mischief in the form of geomagnetic storms that disrupt radio communications, GPS signals and power grids. The reduced pressure currently present in the heliosphere, the enormous bubble of charged particles and magnetic fields that the Sun puffs out around itself, may be a clue.



CME



Sunspots

Yet this lower pressure has allowed coronal mass ejections to expand greatly, in this cycle **about** 38 % bigger than those measured during the last cycle. This has real consequences for Earth. The larger the CME, the lower the strength of the magnetic field inside it, causing milder geomagnetic storms. A weakened interplanetary magnetic field, is another characteristic of Solar Cycle 24.

CMEs can cause shock waves, Large Solar Energetic Particle (SEP) events that can pose a danger to astronauts in Earth orbit. But fewer of these particles are get accelerated by such shocks when the magnetic field is weaker. The strength or weakness of a solar cycle appears to be driven by the intensity of the sun's polar magnetic field during the previous cycle. The polar field feeds sunspots — dark, relatively cool patches on the sun that are the source of CMEs and solar flares — that come in during the next cycle. As the polar field was weak during Solar Cycle 23, scientists expected Solar Cycle 24 would be mild. ##

### ESA's Solar Orbiter To Be Coated With Prehistoric Cave Paint

[http://www.huffingtonpost.com/2014/02/18/solar-orbiter-prehistoric-paint\\_n\\_4805815.html](http://www.huffingtonpost.com/2014/02/18/solar-orbiter-prehistoric-paint_n_4805815.html)

An ESA spacecraft set to launch toward the Sun in 2017 will be protected by a paint once used in prehistoric cave art, a substance derived from burnt bone charcoal. This coating should help protect the Solar Orbiter as it flies closer to the sun than any spacecraft before it.



The probe will fly about 42 million km (c. 26 million mi) from the Sun, a bit more than a quarter of the distance from Earth to the Sun. The Earth is about 150 million km (about 93 million mi) from the sun on average. Mercury, the closest planet to the Sun, approaches within 48.8 million km (28.5 million mi) at its closest point. While observing the Sun, the Solar Orbiter will have to face temperatures up to 968 degrees Fahrenheit (520 degrees Celsius), ESA officials said. In 2010, scientists identified a problem with the heat shield requirements, and had to re-work the heat shield after they ruled out their initial choice, a carbon fiber fabric.

To go on absorbing sunlight, then convert it into infrared to radiate back out to space, its surface material needs to maintain constant 'thermo-optical properties' — keep the same color despite years of exposure to extreme ultraviolet radiation. The shield cannot shed material or outgas vapor, because of the risk of contaminating Solar Orbiter's highly sensitive instruments, and it has to avoid any build-up of static charge in the solar wind because that might threaten a disruptive or even destructive discharge.



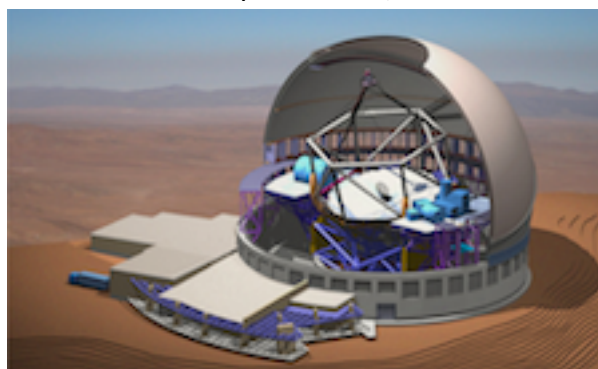
Enbio, a company that produces Solar Black, a material made from burnt bone charcoal, helped them solve the heat shield problems. "Black calcium phosphate processed from burnt bone charcoal" will be bonded (rather than painted) to the outer sheet of titanium on the orbiter's layered heat shield. The new layer effectively becomes part of the metal.

ESA engineers will test Solar Black-treated titanium to see how it will hold up in a vacuum chamber that will simulate some of the environments the spacecraft could encounter while observing the Sun. ##

## EARTHBOUND TELESCOPES

### University of Hawaii Approves Lease for 30 Meter Telescope

February 21, 2014 - HONOLULU — The University of Hawaii Board of Regents voted 15 to 1 to approve subleasing the land atop the Big Island volcano for the Thirty Meter Telescope. The university leases summit land, which hosts about a dozen telescopes in total, from the state.



The telescope will pay more than \$1 million a year for use of the land when the telescope is fully functional. Of this, \$870,000, or 80 percent, will go to the Office of Mauna Kea Management, which preserves the natural, cultural and recreational resources of the mountain while providing a center for astronomy, research and education. The remainder goes to the Office of Hawaiian Affairs.

The telescope would be used to observe planets that orbit stars other than the sun and would enable astronomers to watch new planets and stars being formed. It should see some 13 billion light-years away into the early years of the universe. ##



## NASA Flying Observatory Selects Educator Teams for 2014 Science Flights

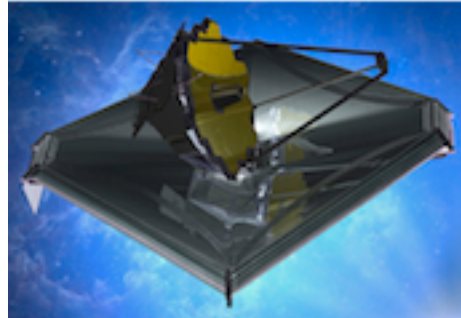
[http://www.sofia.usra.edu/News/news\\_2014/01\\_08\\_14/index.html](http://www.sofia.usra.edu/News/news_2014/01_08_14/index.html)

[Read this full report in the [Teachers and Students section below](#)]

## SPACE TELESCOPES

### JWST – The James Webb Space Telescope passes a Mission Milestone

[www.nasa.gov/press/2014/january/james-webb-space-telescope-passes-a-mission-milestone/](http://www.nasa.gov/press/2014/january/james-webb-space-telescope-passes-a-mission-milestone/)  
[www.space.com/24553-a-look-at-the-james-webb-space-telescope-s-high-tech-spectrometer-video.html](http://www.space.com/24553-a-look-at-the-james-webb-space-telescope-s-high-tech-spectrometer-video.html)



Jan. 24, 2014 – The James Webb Space Telescope passed its first significant mission milestone for 2014 -- a Spacecraft Critical Design Review (SCDR) that examined the telescope's power, communications and pointing control systems. All of the designs are complete for the Webb and there.

The details, designs, construction and testing plans, and the spacecraft's operating procedures have been subjected to rigorous review by an independent panel of experts. In a week-long review with extensive discussions on all aspects of the spacecraft to result in a vehicle that enables the powerful telescope and science instruments to deliver unique and invaluable views of the universe.

The spacecraft built by Northrop Grumman that carries the science payload for Webb may not be as glamorous as the telescope, but it enables the whole mission, providing many services including telescope pointing and communication with Earth, and a high tech infrastructure empowering scientific discovery.

As the successor to NASA's Hubble Space Telescope, JWST will be the most powerful (and expensive) space telescope ever built, able to observe the most distant objects in the universe, provide images of the first galaxies formed and see unexplored planets around distant stars. JWST is a joint project of NASA, the European Space Agency and the Canadian Space Agency. ##

### NASA's NUSTAR Telescope Solves Mystery of how Stars Explode

<http://www.nasa.gov/press/2014/february/nasas-nustar-untangles-mystery-of-how-stars-explode/>  
<http://www.space.com/24743-star-death-lopsided-supernova-explosions.html>

February 19, 2014 – One of the biggest mysteries in astronomy, how stars blow up in supernova explosions, finally is being unraveled with the help of NASA's Nuclear Spectroscopic Telescope Array (NuSTAR). The high-energy X-ray observatory has created the first map of radioactive material in a supernova remnant, named Cassiopeia A (Cas A).

The results reveal how shock waves likely rip massive dying stars apart. "Stars are spherical balls of gas, and so you might think that when they end their lives and explode, that explosion would look like a uniform ball expanding out with great power," "Our new results show how the explosion's heart, or engine, is distorted, possibly because the inner regions literally slosh around before detonating." Cas A was created when a massive star blew up as a supernova leaving a dense stellar corpse and its ejected remains. The light from the explosion reached Earth a few hundred years ago, so we are seeing the stellar remnant when it was fresh and young.

Supernovas seed the universe with many elements, including the gold in jewelry, the calcium in bones and the iron in blood. While small stars like our sun die less violent deaths, stars at least eight times as massive as our sun blow up in supernova explosions. The high temperatures and particles created in the blast fuse light elements together to create heavier elements.

NuSTAR is the first telescope capable of producing maps of radioactive elements in supernova remnants. In this case, the element is titanium-44, which has an unstable nucleus produced at the heart of the exploding star. The NuSTAR map of Cas A shows titanium concentrated in clumps at the remnant's center. Read the article for more insight. ##

## Glare-blocking Starshade designed for Space Telescopes

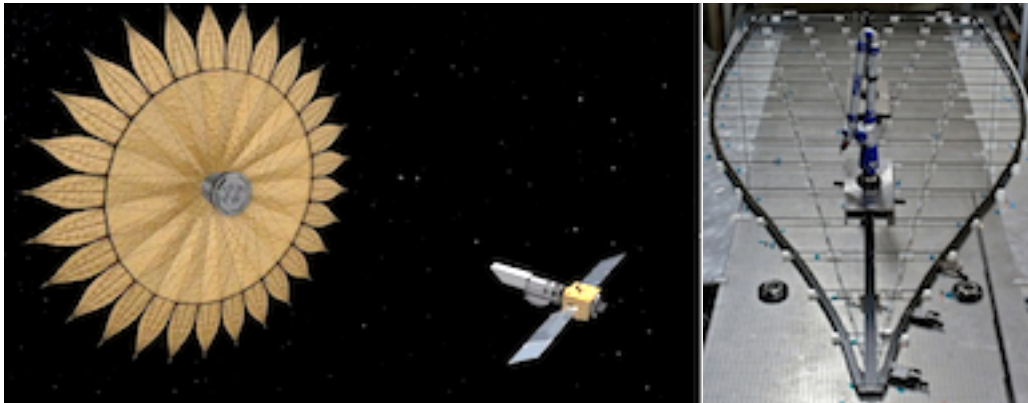
<http://www.space.com/25172-starshade-alien-earth-exoplanets-incredible-tech.html>

<http://www.space.com/25170-glare-blocking-starshade-designed-for-space-telescopes-video.html>

March 24, 2014 A flower-shaped spacecraft may help scientists see Earth-like alien worlds like never before. Called a "starshade," the huge, sunflower-like spacecraft would deploy to its full size in space, blocking the light of distant stars so that a space-based telescope can image exoplanets in orbit around the stars. With this technology, researchers could directly image other worlds and potentially find long sought-after "Earth twins," a prize that has deluded astronomers to date..

Starshades are still in the design stage. But once available, they could help hunt for small planets around bright, nearby stars, and allow scientists to learn more about the planets and even hunt for signs of potential life by peering into the alien worlds' atmospheres.

Starshades works by blocking out light from the star. Only the planet's light enters the telescope.



**Left:** A sunflower-shaped 'starshade' launched to space with a simple telescope could help scientists on the ground hunt for another Earth. Credit: NASA/JPL/Caltech

[www.space.com/images/i/000/037/846/original/starshade-nasa-flower-animation.jpg?1395430835](http://www.space.com/images/i/000/037/846/original/starshade-nasa-flower-animation.jpg?1395430835)

**Right:** A prototype "petal" for a giant starshade being studied by NASA for a future planet-hunting mission. The petals would unfold in space to block the light of distant stars so an accompanying telescope can attempt to directly image alien planets.

[www.space.com/images/i/000/037/867/original/starshade-petal-prototype.jpg?1395659446](http://www.space.com/images/i/000/037/867/original/starshade-petal-prototype.jpg?1395659446)

### A small telescope in space

The assumed \$1 billion mission would be able to target about 55 bright stars in a three-year span. Seager, the chair of NASA's science and technology definition team for the starshade project, thinks it's possible to find Earth-like planets orbiting 22 of those 55 stars targeted by the mission. Once in space, the starshade unfolds and is positioned between the star and the telescope. The shade's unique shape blocks the starlight, potentially revealing exoplanets in orbit around the star that couldn't have been seen previously. With the light blocked, a telescope can directly image the planets.

We won't need to couple the starshade to a large, extremely expensive space telescope. By blocking out the light of a star before that light ever reaches the telescope, the starshade eliminates the need for a huge telescope - any telescope will do."

### Engineering a starshade

Starshades do pose serious engineering challenges. While the telescope and starshade can launch together, the starshade will need to move out from the telescope once both instruments reach space. Most starshade designs are tens of meters in diameter and fly tens of thousands of kilometers from the telescope. "It's challenging. It's also still very difficult to create a large telescope with internal machinery used to correct for starlight. The starshade itself must be designed with extreme accuracy to block light effectively once in space. Researchers on the ground at Princeton and NASA's Jet Propulsion Laboratory in California are working to test models of the starshade now. "Our current task is figuring out how to unfurl the starshade in space so that all the petals end up in the right place, with millimeter accuracy."

### Space sunflower

"The shape of the petals, when seen from far away, creates a softer edge that causes less bending of light waves," Stuart Shaklan, lead engineer on the starshade project at JPL, said in a statement. "Less light-bending means that the starshade shadow is very dark, so the telescope can take images of the planets without being overwhelmed by starlight."

The starshade would come equipped with thrusters to maneuver into different positions to block the light of the 55 stars selected to be blotted out through the course of the mission. Although it will take time to move the starshade into place for each target, the telescope can perform other astrophysics tasks while waiting for the next star to come into view. ##

## FINDING EXOPLANETS

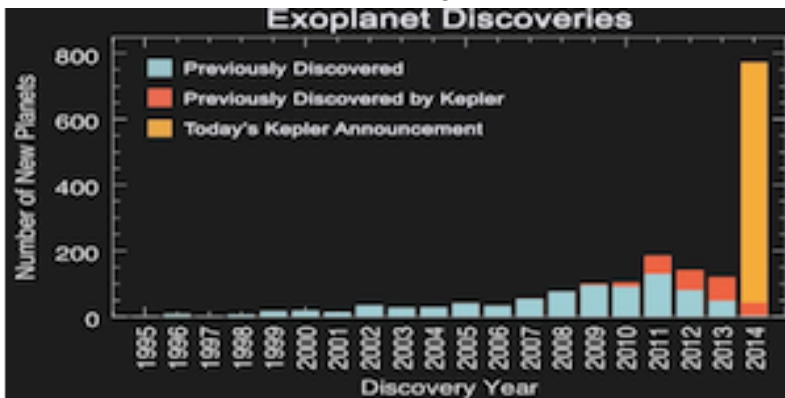
### KEPLER TELESCOPE FINDS 715 More Planets

<http://www.space.com/24826-double-earth-size-exoplanet-found-in-system-s-habitable-zone-orbit-animation.html>

[www.space.com/24827-kepler-space-telescope-exoplanet-bonanza-explained-infographic.html](http://www.space.com/24827-kepler-space-telescope-exoplanet-bonanza-explained-infographic.html)

<http://www.space.com/24830-715-new-worlds-how-they-were-found-video.html>

February 20, 2014 – NASA's Kepler space telescope has discovered more than 700 new exoplanets, nearly doubling the current number of confirmed alien worlds. The 715 newfound planets, announced today boost the total alien-world tally to between 1,500 and 1,800, depending on which of the five main extrasolar planet discovery catalogs is used.



**The Kepler mission is responsible for more than half of these finds, 961 to date, with thousands more candidates awaiting confirmation by follow-up investigations.**

This is the largest windfall of actually validated exoplanets ever announced at one time, About **94 percent of the new alien worlds are smaller than Neptune**, researchers said, further bolstering earlier Kepler observations that suggested **the Milky Way galaxy abounds with rocky planets like Earth.**

- **Most of the 715 exoplanets** orbit close to their sun, making them **too hot** to support life as we know it.
- **Four of the worlds are less than 2.5 times the size of Earth and reside in the "habitable zone,"** that just-right range of distances that could allow liquid water to exist on their surfaces.

The \$600 million Kepler Telescope was launched in March 2009 to determine how frequently Earth-like planets occur around our galaxy. The observatory detects alien worlds by noticing the telltale brightness dips caused when they pass in front of, or transit, their parent stars from Kepler's perspective.

Kepler's original planet-hunting mission ended last May when the second of its four orientation-maintaining reaction wheels failed, robbing the spacecraft of its ultraprecise pointing ability. Still, scientists have expressed confidence that they will be able to achieve the mission's chief goals with the data Kepler gathered during its first four years in space in which it flagged more than 3,600 planet candidates to date: about 90 percent of them will end up being the real deal.

As the 715 new planets are from just the first two years of Kepler observations, more big planet-confirmation hauls could be coming as researchers go through the rest of the mission's huge database.

All of the 715 newfound alien planets reside in multiplanet systems, just like Earth. Taken together, the new planets orbit a total of 305 stars.

These systems are generally reminiscent of the inner regions of our own solar system, where planets travel around the sun in circular orbits that are more or less in the same plane, These results establish that **planetary systems with multiple planets around one star, like our own solar system, are in fact common,**

The method should help researchers confirm hundreds more Kepler candidates down the road, Rowe and others said. **A higher percentage of these future finds should be in the habitable zone,** since it takes longer for the spacecraft to detect more distantly orbiting exoplanets than ones that zip

around their star in a matter of days or weeks (and researchers haven't analyzed the last two years of Kepler data using the multiplicity technique). ##

## ESA Selects Planet-Hunting PLATO Mission

[http://www.esa.int/Our\\_Activities/Space\\_Science/ESA\\_selects\\_planet-hunting\\_PLATO\\_mission](http://www.esa.int/Our_Activities/Space_Science/ESA_selects_planet-hunting_PLATO_mission)

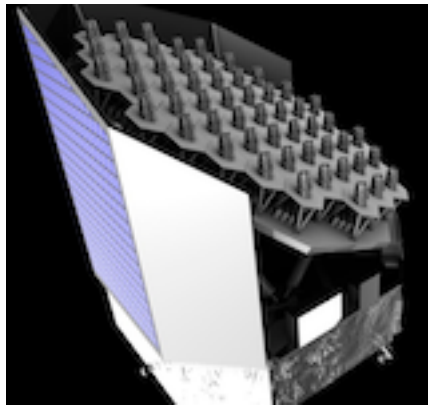
<http://bowshooter.blogspot.com/2014/02/esa-plato-34-european-space-telescopes.html>

**February 19, 2014** – A space-based observatory to search for planets orbiting other stars has been selected as ESA's third medium-class science mission, planned for launch by 2024.

The **PLATO** – Planetary Transits and Oscillations of stars – mission was selected by ESA's Science Programme Committee for implementation as part of its **Cosmic Vision 2015–25 Programme**. The mission will address two key themes: **what are the conditions for planet formation and the emergence of life, and how does the Solar System work?**

PLATO will monitor **relatively nearby stars**, searching for tiny, regular dips in brightness as their planets transit in front of them, temporarily blocking out a small fraction of the starlight. By using **34 separate small telescopes and cameras**, PLATO will search for planets around up as many as a million stars spread over half of the sky. It will also investigate **seismic activity in the stars**, enabling a **precise characterisation of the host sun** of each planet discovered, **including its mass, radius and age**.

When coupled with ground-based radial velocity observations, PLATO's measurements will allow a **planet's mass and radius to be calculated, and thus its density, an indication of its composition**.



Design of the Plato Space Telescope

The mission will **identify and study thousands of exoplanetary systems**, with an emphasis on **discovering and characterising Earth-sized planets and super-Earths in the habitable zone**.

PLATO, with its unique ability to hunt for **Sun-Earth analogue systems**, will build on the expertise accumulated with a number of European missions, including **CoRoT** and **Cheops**,

**PLATO's discoveries will help to place our own Solar System's architecture in the context of other planetary systems.**

**Mission concepts competing for the M3 launch opportunity were:**

- EChO (the Exoplanet CHaracterisation Observatory),
- LOFT (the Large Observatory For x-ray Timing), MarcoPolo-R (to collect and return a sample from a near-Earth asteroid) and
- STE-Quest (Space-Time Explorer and QUantum Equivalence principle Space Test).

PLATO joins Solar Orbiter and Euclid, chosen in 2011 as ESA's first M-class missions. Solar Orbiter will be launched in 2017 to study the Sun and solar wind from a distance of less than 50 million km, while Euclid, to be launched in 2020, will focus on dark energy, dark matter and the structure of the Universe.

PLATO will be launched on a Soyuz rocket from ESA's in Kourou by 2024 for an initial six-year mission. It will operate from L2, a virtual point in space 1.5 million km beyond Earth as seen from the Sun.

Data from ESA's recently launched Gaia mission will help PLATO to provide precise characteristics of thousands of exoplanet systems. ##



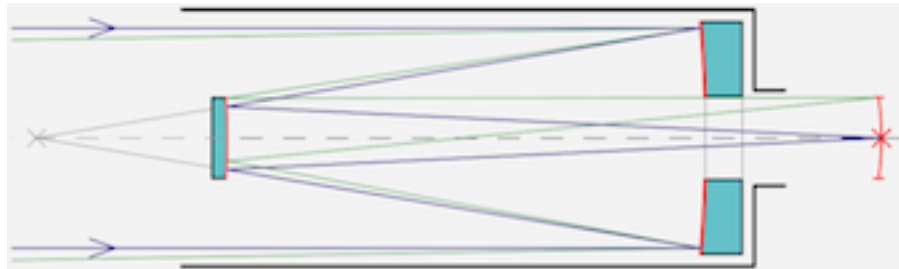
## SPACE TELESCOPES – ASTRONOMY FROM THE MOON

### The Telescope on the Moon aboard the Chang'e-3 lander

[http://en.wikipedia.org/wiki/Chang'e\\_3](http://en.wikipedia.org/wiki/Chang'e_3)

#### Lunar-based ultraviolet telescope (LUT)

The lander is equipped with a 150 mm (5.9 ") **Ritchey-Chrétien telescope** that will be used to observe galaxies, active galactic nuclei, variable stars, binaries, novae, quasars and blazars in the **near-UV** band (245–340 nm), capable of detecting objects as low as magnitude 13. The thin atmosphere and slow rotation of the Moon allow extremely long, uninterrupted observations of a target. The LUT will be the first long term lunar-based astronomical observatory, making continuous observations of important celestial bodies to study their light variation and better improve our current models.



A Ritchey-Chretien telescope is a specialized Cassegrain Telescope using a hyperbolic primary mirror and a hyperbolic secondary mirror to eliminate third-order coma and spherical aberration. RCT designs are well-suited for wide-field and photographic observations with good off-axis performance at a large field of view free of optical errors.

[www.spaceflight101.com/change-3.html](http://www.spaceflight101.com/change-3.html) Section: Lander Instruments: Lunar-Based Ultraviolet Telescope

The Lunar-based Ultraviolet Telescope (LUT) is used to observe galaxies, binary stars, active galactic nuclei and bright stars. A lunar-based observatory has a number of advantages over Earth-based and space-based observatories. On Earth, observatories battle the effects of the atmosphere that are often the limiting factors for scientific observations. The Moon's thin exosphere provides excellent opacity with no atmospheric turbulence and virtually no scattered light emissions.

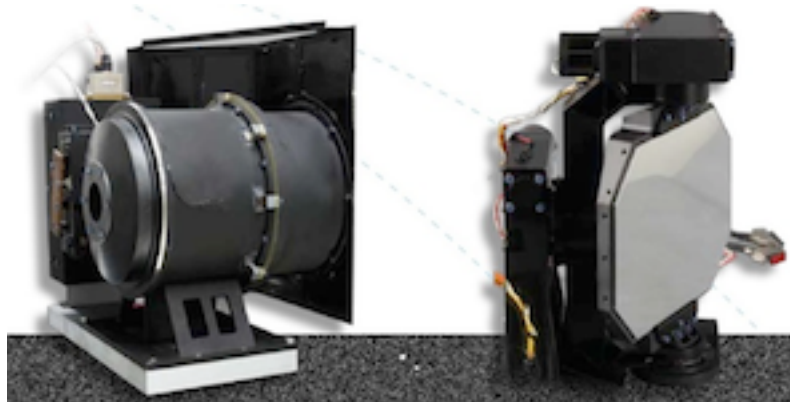


Image: CLEP - LUT Subsystems: telescope body (left) & mounting platform with two-axis gimbal

The LUT has an excellent pointing system for long-term observations of targets. The Moon on the other hand provides a stable platform. Also, **the sky's motion as seen from the Moon is 27 times slower than on Earth**, allowing extremely long, uninterrupted imaging campaigns of a target.

The LUT is the first long-term observatory to be deployed on the Moon. **The Apollo 16 mission brought a far-UV telescope to the Moon for short-term observations, collecting nearly 200 images of quality that is considered very poor by today's standards.**

LUT can perform multiple-day observation campaigns, looking at variable stars and active galaxies in the near-UV band. Objects that are bright in the NUV band include variable stars, binaries, novae, quasars and blazars. LUT will attempt to study the variability of these objects to examine the temperature and accretion rate in order to better understand stellar atmospheres and improve current models.

LUT has an aperture of 150mm and uses a pointing mirror that features a two-dimensional gimbal to track objects. A Charge-Coupled Device enhanced for observations in the ultraviolet band is used as detector. The CCD uses pixels 13 micrometers in size. LUT covers a wavelength range of 245 to

**ASTRONOMY FROM THE MOON Topic Background LINKS:**

[http://imagine.gsfc.nasa.gov/docs/ask\\_astro/answers/970528a.htm](http://imagine.gsfc.nasa.gov/docs/ask_astro/answers/970528a.htm)

<http://www.nap.edu/openbook.php?isbn=0309043816&page=100>

[http://www.star.ucl.ac.uk/~iac/AG\\_Lunar\\_astronomy\\_writeup.pdf](http://www.star.ucl.ac.uk/~iac/AG_Lunar_astronomy_writeup.pdf)

<http://lunar.colorado.edu/~jaburns/publicfiles/tiny/files/astronomy.moon.pdf>

[http://journals.cambridge.org/download.php?file=%2FIAU%2FIAU3\\_T26B](http://journals.cambridge.org/download.php?file=%2FIAU%2FIAU3_T26B)

[%2FS1743921308024149a.pdf&code=ef738a53e64f1972c3e652438a6bb5dd](http://journals.cambridge.org/download.php?file=%2FIAU%2FIAU3_T26B%2FS1743921308024149a.pdf&code=ef738a53e64f1972c3e652438a6bb5dd)

<http://astrogeo.oxfordjournals.org/content/49/2/2.17.full>

[http://www.lpi.usra.edu/meetings/LEA/whitepapers/Lester\\_DFL\\_NAC\\_WP\\_1\\_10\\_07.pdf](http://www.lpi.usra.edu/meetings/LEA/whitepapers/Lester_DFL_NAC_WP_1_10_07.pdf)

## International Lunar Observatory Association Acquires Exclusive Images from Chang'E-3 Lunar Ultraviolet / Optical Telescope

<http://www.spaceref.com/news/viewpr.html?pid=42839>

19 March 2014 Kamuela, Hawaii, USA. The International Lunar Observatory Association (ILOA) has received exclusive images from key partners at NAOC in Beijing, with data from the **Lunar Ultraviolet Telescope** aboard Chang'e-3 operating on the surface of the Moon.

The testing and commissioning phase is complete and all the telescope systems are operating nominally. The LUT already has captured over 22,000 astronomical images. The 150-mm (6") diameter, near ultraviolet telescope is the payload that has operated the longest and obtained the most data since the 14 December 2013 Moon landing of Chang'e-3.

ILOA has Memoranda of Understanding with National Astronomical Observatories, Chinese Academy of Sciences (NAOC) and China National Space Administration (CNSA) to exchange observation opportunities between China's Lunar Ultraviolet / Optical Telescope (LUT) aboard Chang'e-3 and the ILO-X Precursor and ILO-1 Moon South Pole mission currently in development for launch 2015-2016.

The immediate goal is a plan for additional astronomical observations. ILOA Founding Director Steve Durst says ILOA hopes to advance human understanding of the Cosmos from the Moon.

### **Images which could not have been taken by Earthbound telescopes**

"These UV observations of the XZ Cygni (RR Lyrae type) variable star cannot be done from the Earth's ground, and the lunar surface provides a stable platform that should make it easier to operate a long-lasting telescope. Studies of variable stars like this in the UV will help us measure distances in our Galaxy, providing humans with a more 3-dimensional visualization of our home Galaxy."

### **The future of Astronomy from the Moon**

Durst noted that "...the Chang'e-3 landing may mark the beginning of permanent operations on the Moon and help establish a toehold for human lunar settlement, firmly establishing humanity as a Multi World Species."

ILOA is an interglobal enterprise incorporated in Hawaii as a 501(c)(3) non-profit to advance human knowledge of the Cosmos through observation from our Moon, and to participate in internationally cooperative lunar base build-out. ILOA co-sponsors with its Space Age Publishing Company affiliate an international series of Galaxy Forums to advance 21st Century Education. Galaxy Forums, designed to provide greater global awareness, capabilities and action in Galaxy science, exploration and enterprise, are held in Hawaii, Silicon Valley, Canada, China, India, Japan, Europe, Africa, Chile, Brazil, Southeast Asia, Kansas and New York. Current plans are for expansion to Antarctica in 2014. For more information visit [ILOA.org](http://ILOA.org) or contact: [info@iloa.org](mailto:info@iloa.org)

## SEARCH FOR EXO-PLANETS & LIFE

Below is a series of articles on the possible kinds of worlds that might host life. The first two articles were published last year, but we had not previously reported on them in TTSIQ #3 or #6 as would have been timely. These articles show that worlds quite different from our wondrous Earth might also be quite capable of hosting life. That variability makes our universe all the more wondrous!

And for those of us old folks, science seems to have caught up with, and totally surpassed the imaginations of science-fiction writers. The universe is far far more amazing and varied than anyone could have dreamed! PK

## Astrobiology research: Life possible on extrasolar moons

Jan 10, 2013 – <http://phys.org/news/2013-01-astrobiology-life-extrasolar-moons.html#nRlv>

In their search for habitable worlds, astronomers have started to consider “exomoons”, moons of planets of other suns/stars. In a new study, a pair of researchers has found that some types of exomoons are just as likely to support life as exoplanets. [That should come as no surprise, given what we are already wondering about on Europa, an ice-covered ocean world orbiting Jupiter. It is probable that “Europids” far outnumber Earth-like planets in the universe.]

Research by René Heller of Germany's Leibniz Institute for Astrophysics Potsdam and Rory Barnes of the University of Washington and the NASA Astrobiology Institute, appeared in the January 2013 issue of Astrobiology.

Of some 850 extrasolar planets detected at the time, most are sterile gas giants like our Jupiter. Only a few are solid surfaced worlds orbiting their sun in the “habitable zone” where liquid water oceans can exist, to create a friendly environment for life of the kind with which we are familiar.

The authors tackled the theoretical question whether such planets could host habitable moons. None such have been discovered at the time their work was published, but we have no reason to assume that none subh exist.

Because moons are typically tidally locked to their planet, with one hemisphere tidally locked to face the planet, their climatic conditions are likely to differ from that of the planet. Such moons have two sources of light—from their sun and from the planet they orbit—and are subject to frequent eclipses when their parent planet eclipses their sun, reducing total illumination hours well below 50%. Keep in mind that the angular diameter of the much closer host planet is likely to be substantial, far greater than that of the more distant sun. “For instance stellar eclipses could lead to sudden total darkness at noon.”

Tidal heating, as we have on Europa, triggered by a moon's varying distance from its host planet would be a criterion for exomoon habitability. The closer the moon to its host planet, the stronger any tidal heating. Moons orbiting too closely could suffer a catastrophic runaway greenhouse effect that would boil away surface water and leave them forever uninhabitable.

The author’s theoretical model estimates the minimum distance a moon could be from its host planet and still allow habitability – the “habitable edge.” Astronomers can use this standard to evaluate habitability of extrasolar moons. “The habitable zone for exomoons is thus different than that of exoplanets.

The exquisite photometric precision of NASA’s Kepler space telescope makes the detection of a Mars- to Earth-sized extrasolar moon quite likely. Since 2012 the first dedicated “Hunt for Exomoons” with the Kepler is under way. [Note, however, that Kepler continues to work in a handicapped condition, having lost some of its pointing capability.] ##

## Magnetic Fields are crucial to Exomoon Habitability

<http://phys.org/news/2013-09-magnetic-fields-crucial-exomoon-habitability.html#nRlv>

September 27, 2013 – Hidden deep within the wealth of data collected by NASA's Kepler mission are minuscule signatures of exomoons. Researchers are beginning to address the factors that may deem these alien moons habitable. [See report above.]

A new study led by Dr. René Heller from McMaster University in Canada and Dr. Jorge Zuluaga from the University of Antioquia in Colombia explores the key components that may make exomoons livable. While stellar, planetary, and tidal heating play a large role, it has become clear that the magnetic environments of exomoons may be even more critical.

For exoplanet habitability, location in the circumstellar habitable zone in which temperatures allow liquid surface oceans. However, there is\an additional set of constraints that affects their habitability.

In a set of recent papers, Dr. Heller and Dr. Rory Barnes (University of Washington) defined a “circumplanetary habitable edge,” which is roughly analogous to the circumstellar habitable zone. But here the question of habitability is based on the relationship between the exomoon and its host planet. The additional energy source from the planet's reflected starlight, the planet's thermal emission, and tidal heating in the moon may create a runaway greenhouse effect, rendering the exomoon uninhabitable.

“One look at Io” – Jupiter's closest Galilean satellite – shows the drastic effects a nearby planet may have on its moon. The strong gravitational pull of Jupiter distorts Io into an ellipsoid, whose orbit around the giant planet is eccentric due to perturbations from the other Galilean moons. As the orbital distance between Jupiter and Io varies on an eccentric orbit, Io's ellipsoidal shape oscillates, which generates enormous tidal friction.” Io has over 400 active volcanic regions.

The authors talk about an “edge”, not a zone, that defines only an innermost habitable orbit, inside which a moon would become uninhabitable. The exomoon must exist outside this edge to avoid intense planetary illumination or tidal heating. Exomoons well outside this “edge,” have a chance at sustaining life.

[Editor: to judge from Ganymede and Callisto, there would seem to be an “outer edge” as well, where internal tidal heating is not strong enough to create an ice shell that can be fractured at times to allow the ocean below to interact with the moon’s surface, as is the case on Europa.

We refer the reader to the rest of the linked article. It appears that the authors are talking about exomoons that have oceans exposed to space under an atmosphere that could be stripped away without the protection of the host planet’s magnetosphere. There is no such type of moon in our solar system to serve as a model.]

## Life on other planets could be far more widespread, study finds

January 07, 2014 – <http://phys.org/news/2014-01-life-planets-widespread.html#nRlv>

(Phys.org) —**Earth-sized planets can support life at least ten times further away from stars than previously thought.** Academics at the University of Aberdeen, in a new paper published in Planetary and Space Science, claims cold rocky planets previously considered uninhabitable may actually be able to support **life beneath the surface.**

The team challenge the traditional 'habitable zone' – i.e. the area of space around a star, or sun, which can support life – by taking into consideration life living deep below the ground. As you get deeper below a planet's surface, the temperature increases, and once you get down to a temperature where liquid water can exist – life can exist there too."

The team created a computer model that estimates the temperature below the surface of a planet of a given size, at a given distance from its star.

"The deepest known life on Earth is 5.3 km below the surface, but there may well be life even 10 km deep in places on Earth that haven't yet been drilled. Using our computer model we discovered that the habitable zone for an Earth-like planet orbiting a sun-like star is about three times bigger if we include the top five kilometres below the planet surface. The model shows that liquid water, and as such life, could survive 5km below the Earth's surface **even if the Earth was three times further away from the sun** than it is just now. If we go deeper, and consider the top 10 km below the Earth's surface, then the habitable zone for an Earth-like planet is 14 times wider."

The current “surface-habitable zone” for our solar system extends out as far as Mars, but if we consider the conditions for sub-surface life, the zone extend out further than Jupiter and Saturn. Further, many “rogue” star-less planets drifting around in complete darkness without could actually be habitable.

“Rocky planets a few times larger than the Earth could support liquid water at about 5 km below the surface even in interstellar space (i.e. very far away from a star), even if they have no atmosphere because the larger the planet, the more heat they generate internally.”

For example, the planet **Gliese 581 d**, which is 20 light years away from Earth in the constellation Libra, may be too cold for liquid water at the surface. This new model suggests that it is very likely to be able to support liquid water less than 2 km below the surface, assuming it is Earth-like [in composition]."

Another paper published by the same team suggests there could be more life below the surface of the continents on Earth than there is below the seafloor, waiting to be discovered (in drill cores?)

The authors suggest that it might be worth looking for signs of life outside conventional habitable zones. In what ways might life below the surface reveal itself?

"The surfaces of known rocky planets and moons are nothing like Earth. Going below the surface protects you from a whole host of unpleasant conditions on the surface. So the subsurface habitable zone may turn out to be very important. Earth might even be unusual in having life on the surface."

[Editor: Back to the article’s beginning: “old rocky planets previously considered uninhabitable may actually be able to support **life beneath the surface.**” **But could it originate there, and evolve there? That is the question.**

It is hard to imagine that sub-surface life forms could evolve multi-cellular forms to which we could relate. Subsurface conditions do certainly vary enough that there could be a large variation in life forms colonizing the water-saturated zone. But planets with this kind of life only, can not be called – life bearing – in the sense of “life as we know it, and can relate to. On Earth, we may have multi-cellular life forms that have evolved in the ocean depths that have found niches in water-saturated soil below. But these life forms evolved from bottom life in a liquid ocean, not in water-saturated rock. “Hohum!” – we remain both uninterested and unconvinced and find mosquitos, bedbugs, and tapeworms far more fascinating.]



## Super-Earth Planets May Have Watery Earth-like Climates

<http://www.space.com/24216-super-earth-exoplanets-earthlike-climate-aas223.html>

January 09, 2014 – WASHINGTON — The alien worlds known as "super-Earths" may be more like our own planet than previously thought, a new study suggests. "Super Earths"— exoplanets slightly larger than Earth — are common throughout the Milky Way galaxy, but because of their massive gravity, scientists have assumed they should be water worlds. According to a new model, however, tectonically active super-Earths likely store most of their water in the mantle, leaving exposed continents and oceans that could create a stable climate such as that of Earth.

"The temperate climate on Earth is not just because of liquid water, but because of exposed continents," study researcher Nicolas Cowan of Northwestern University in Chicago. The surface temperatures of continents act as a kind of geological thermostat on Earth and would probably do so on other similar planets, stabilizing the climate.

A super-Earth twice the diameter of Earth would have 10 times the mass and 10 times the amount of water and three times as much gravity as Earth's, squashing the planet's topography by a factor of three and creating shallow ocean basins. Given so much water and a shallow place to contain it, conventional wisdom holds that a super-Earth's oceans should overflow their basins and inundate the planet.

However, on Earth, a lot of water is stored in the mantle— the rocky layer that makes up most of the planet's volume and mass — and moves between the oceans and mantle as tectonic plates shift. (What the editor has called "hydrotectonic worlds, "M Class," if you will in "Star Trek" parlance.)

Seafloor pressure, determined by gravity, would control this process. The authors find that the heftier gravity would create massive pressure on the seafloor, forcing water into the planet's mantle. "We can put 80 times more water on a super-Earth and still have its surface look like Earth," As a result, these planets should have landmasses that stabilize the climate, instead of being submerged in oceans.

**Editor:** The unasked question in this report is would continents floating on such a more massive wet mantle move around and collide with one another on a time scale faster or slower than they do on Earth? The answer may affect the pace of life's evolution on such worlds.

If these planets, apparently relatively common in our galaxy, turn out to have stable climates, their ability to support "life as we know it" would be higher than previously thought. The author (Cowan) does not believe that a gravity level three times ours would rule out life, "fighter pilots can handle it."

**Editor:** But it could be that land surface life forms on these super Earths would be relatively ground-hugging and/or have much more massive musculature. The gravity might not affect oceanic life forms as much.

The next step to confirm the model's findings would entail launching a high-contrast imaging mission in space to take pictures of these super-Earths and verify that they actually do have continents and oceans. "Our model is a shot from the hip, but it's an important step in advancing how we think about super-Earths," Cowan said. <http://www.space.com/10761-sky-full-alien-planets.html> Infographic

**Editor's comments:** We are only at the beginning of our search for Earth-like planets, and have not yet found one "really" similar to Earth. How similar to Earth would a planet have to be to be truly Earthlike?

- Mass and size similar to Earth
- Continent(s) and ocean(s) - ("hydrothermal tectonics" - our term)  
Position in the "habitable" or "Goldilocks zone" similar to Earth, where liquid surface oceans can exist.
- Age of planet: multicellular life did not evolve on Earth until perhaps the last 600 million years of Earth's 4,500 million year lifetime. Substantially younger planets might only have one-cell life forms.
- A sun that was reasonably similar to ours in mass, spectral type and age
- We have yet to find a planet with these characteristics
- We don't know how much each of these characteristics can vary before precluding development of life parallel to what we see on our planet

All these caveats to the side, there are so many stars in our galaxy, that one in a billion sun-earthlike systems of similar age would still give us millions of sister worlds in just our galaxy alone.

Are astronomers too eager to find such a world that they are relaxing these characteristics? Or are conditions under which Earth evolved unnecessarily narrow? It is exciting to live in an era when for the first time we might have at least preliminary answers to these questions. ##

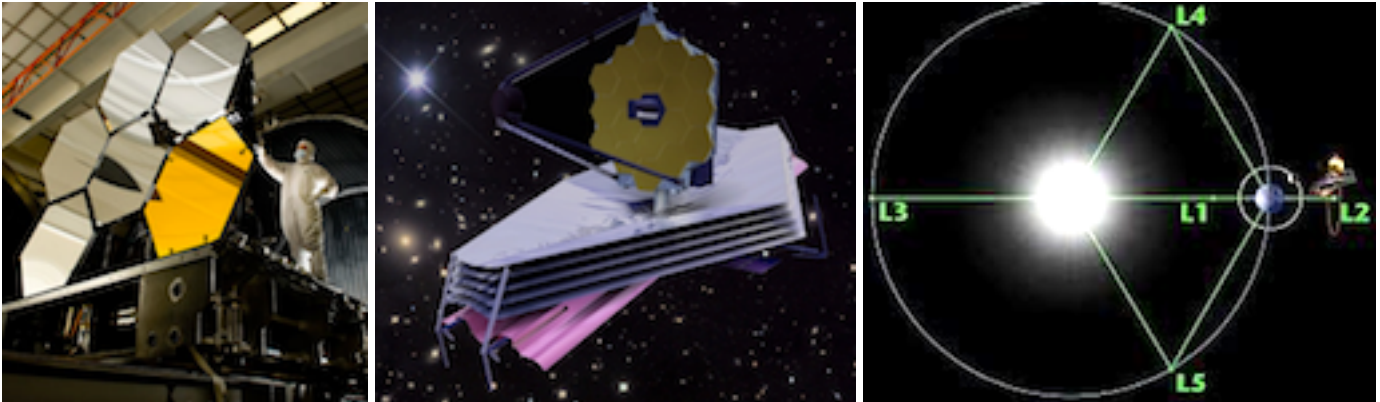
## New Tool Could Help Spot Alien Life

<http://news.sciencemag.org/biology/2014/03/scienceshot-new-tool-could-help-spot-alien-life>

<http://online.liebertpub.com/doi/abs/10.1089/ast.2013.0990>

March 7, 2014 – Earth’s heavy atmosphere keeps water from evaporating into space. So astronomers looking for alien worlds that can harbor life have also been looking for heavy atmospheres. A new way to gauge the atmospheric pressure of distant planets uses molecules that couple up to form larger molecules called dimers, in this case, two oxygen molecules.

When a planet passes in front of its star, starlight shines through the planet’s atmosphere and continues through space until it reaches us. Dimers in the atmosphere absorb light like a color filter on a camera lens, creating anomalies detectable if the planet’s atmospheric pressure is at least 0.25 bars—high enough to hold down liquid water. Researchers should be able to measure this using the new James Webb Space Telescope once it begins service in 4 years, at the Sun–Earth L2 position (right illustration below.)



But here is the kicker. These signals are detectable only if the atmosphere is well oxygenated, and the only way we know that an atmosphere can be oxygenated is through photosynthesis – implying life. If scientists find oxygen dimers on a planet, they may have not only found a world with water we can drink and air we can breathe, but also a living world.

One more reason to count the months until the James Webb Space Telescope is in space and ready to be on the lookout for such signals. The first positive find will be one of the most dramatic moments in the history of astronomy. ##

## Looking for a 'Superhabitable' World? Try Alpha Centauri B

<http://phys.org/news/2014-01-superhabitable-world-alpha-centauri-paper.html>

Jan 23, 2014 – The search for extraterrestrial life extends far beyond Earth's solar system, looking for planets or moons outside the "stellar habitable zone" that may have environments even more favorable to supporting life than here on Earth. These superhabitable worlds have unique characteristics and are ideal [targets](#) for extrasolar exploration.

In "[Superhabitable Worlds](#)" René Heller, McMaster University (Hamilton, Ontario, Canada) and John Armstrong, Weber State University (Ogden, UT), propose how [tidal heating](#) can create conditions in which life could emerge on an icy or terrestrial planet or moon once thought to be uninhabitable.

"A great place for hydrothermal microorganisms and a volcanic eruption in the weather forecast every morning and evening, a tidally heated planet would be unpleasant though spectacular to visit."##

**Editor's Trivia:** More than two decades ago, in [Moon Miners Manifesto #43](#), March 1991, the editor suggested that we name the two suns in the Alpha Centauri system "Ixion" and "Nephthele" for A and B respectively, after the King and Queen of the Centaurs in ancient mythology. Above, we are talking about the Nephthele system. ## Cf: [http://www.moonsociety.org/publications/mmm\\_themes/mmmt\\_Starbound.pdf](http://www.moonsociety.org/publications/mmm_themes/mmmt_Starbound.pdf)

## What Would A Rocky Exoplanet Look Like? Atmosphere Models Seek Clues

March 12, 2014 – <http://www.space.com/25033-rocky-planet-atmosphere-models.html>

When a distant planet appears as a point of light in a telescope, it's hard to imagine what things are like at the surface. Does rain fall? Is the atmosphere thick, or dissipating into space? How constant is the sunlight on its surface? But gradually, astronomers are finding ways to interpret the data to find interesting clues, some of which may indicate the presence of life.

As a planet transits across the face of its sun, astronomers can study the changes in wavelengths of the sun's light as it is filtered by that planet's atmosphere, if it has one, to figure out the chemical composition of that atmosphere. However, until now only hot giant planets, like our Jupiter, Saturn, Uranus, and Neptune have been observed.

Francois Forget, a senior research scientist with the Meteorological Dynamics Laboratory of the Pierre Simon Laplace Institute in Paris, is part of a group trying to create a model for how planetary atmospheres behave on smaller, rocky planets like Earth, Venus, and Mars in our own solar system. The model is a start, designed to let us simulate, as much as we can, a planet with "any kind of atmosphere around any kind of star."

The goal is to learn about climates on terrestrial exoplanets. Forget and colleague Jeremy Leconte have published a paper, "Possible climates on terrestrial exoplanets", available right now on the pre-publishing site Arxiv, and in press with the Proceedings of the Royal Society. The "punchline" of the research, is what factors control the composition of a planet's atmosphere. Studying all sorts of planets will help scientists learn more about life and habitability in distant worlds: what is the climate on a planet – and in particular how life-friendly is it? The answer depends on three factors:

- The atmospheric composition (including the presence or absence of an ocean)
- Its parent star's variability, type and distance away from the planet
- The type of planetary rotation.

If the star is smaller and weaker than our own sun, but the planet we have discovered around it is at a shorter distance than Earth is from our sun, since that sun's rays have a shorter distance to travel to the planet's surface, they could warm it to as much as the Sun does Earth.

Or maybe a planet is so close to its star that it is locked so that the perpetual day-facing side is too hot to support life. On the night side, however, the atmosphere surrounding the planet might permit pockets of liquid water, along the twilight-lit edges, while the farside of the planet is perpetually frozen.

A key figure in their paper looks at the different types of atmospheres that are possible depending on the mass of the planet, and its temperature – a "very highly speculative brainstorming on what kind of cocktail of atmosphere we can have on a terrestrial planet," Forget said.

To be determined: the boundaries between the various types of atmospheres: "the physical processes that actually control the composition of the atmosphere are extremely difficult to model and simulate and calculate."

The research shows that different kinds of planets tend to have specific sorts of atmospheres. A gas giant's high gravity can hold on to the light elements of hydrogen and helium, the original elements in the solar system when the sun and planets were just coming together from a gas cloud. Earth, and even Mars, likely had these elements in abundance in its atmosphere at the beginning, but was not massive enough to hold onto them. ##

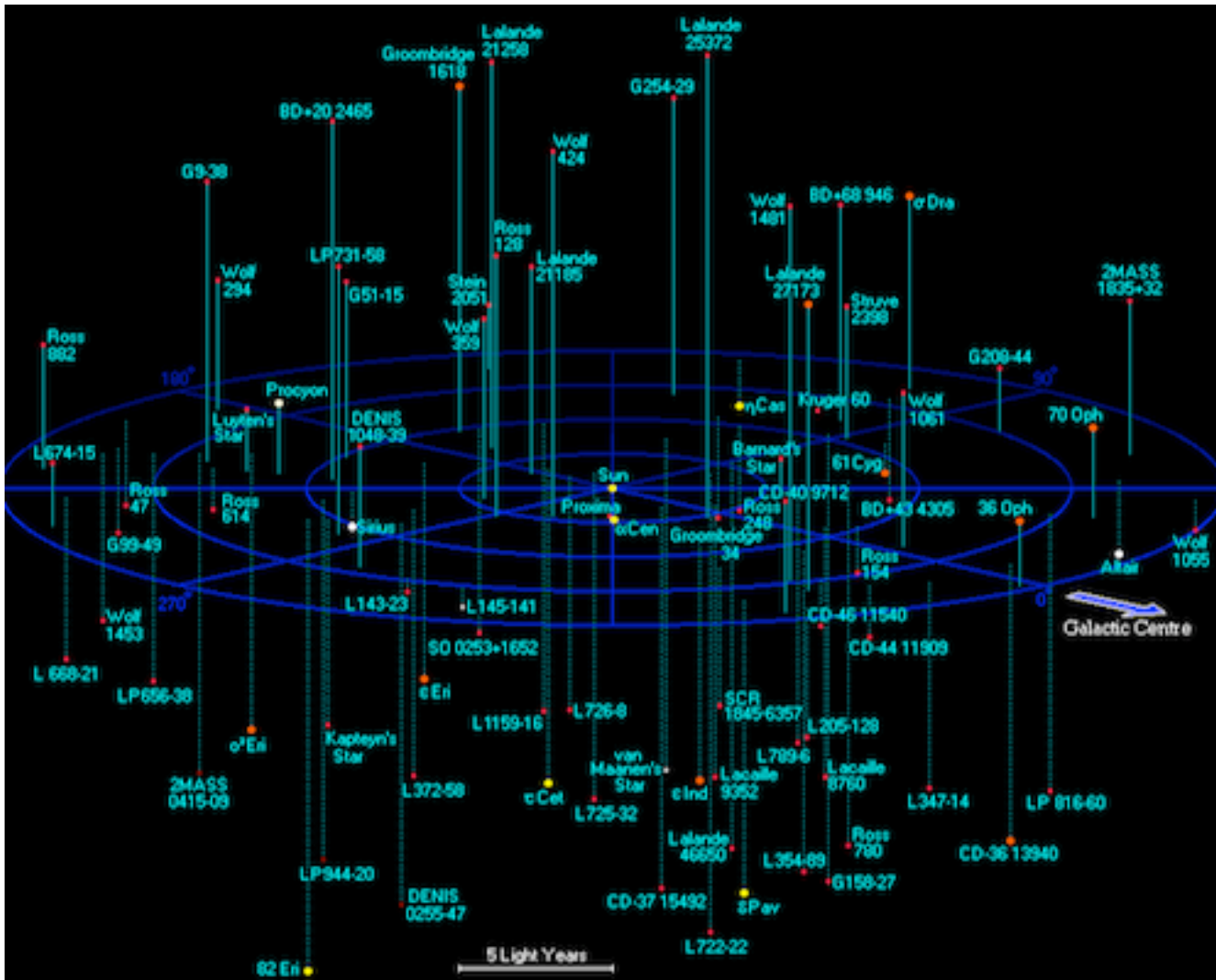
## Our Stellar Neighborhood: 83 Star Systems within 20 Light Years

(Black Background version) – <http://www.atlasoftheuniverse.com/20lys.html>

Below is a map of all known stars that lie within 20 light years,

83 known star systems lie within this distance, containing 109 stars and 8 brown dwarfs

Brighter/hotter to dimmer/cooler: 2 A, 1 F, 6 G (Sun), 16 K, 76 M, 8 Brown Dwarfs, 6 White Dwarfs



White background version: <http://www.atlasoftheuniverse.com/w20lys.gifs>

**Editor:** The above image has been scaled down to fit this page.

Check links above for full size version on black background and on white background (above);

**Note:** The list is appreciably larger than the one we had seen 50 years ago!

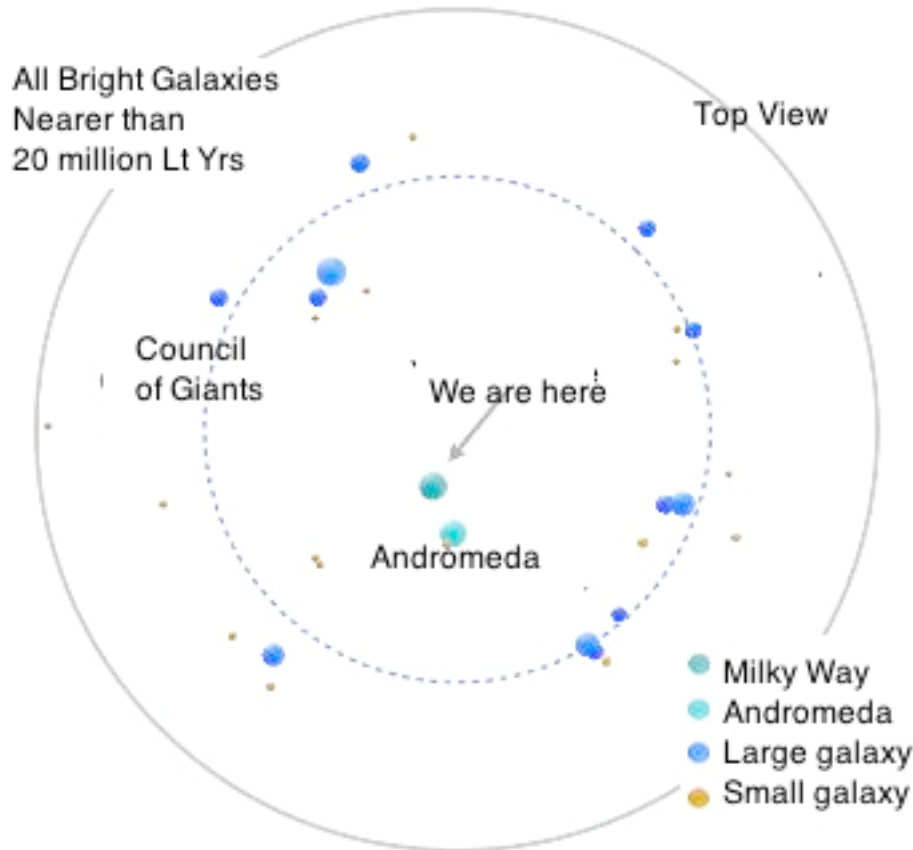
We can expect the list to grow as we find more nearby faint stars, and "brown dwarfs." ##



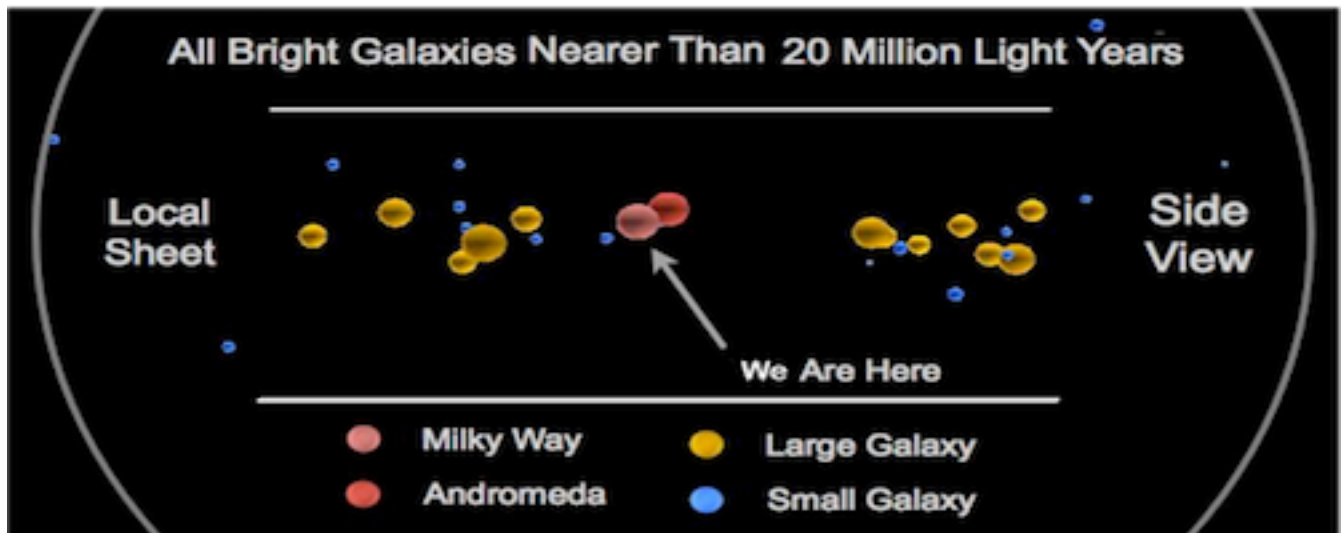
## Bright Galaxies within 20 Million Light Years

March 11, 2014 - <http://www.ras.org.uk/news-and-press/news-archive/254-news-2014/2419-milky-way-amidst-a-council-of-giants>

We all know that M31, the Great Galaxy in Andromeda, is our nearest comparable neighbor. Here is our “galactic neighborhood” – including video



Original Diagram in Black: <http://www.ras.org.uk/images/stories/press/Local%20sheet%20topview.jpg>



## BROWN DWARFS

## First-Ever Weather Map of Failed Star Reveals Patchy Alien Clouds

JAN 24, 2014 - [www.space.com/24466-brown-dwarf-weather-map-revealed.html](http://www.space.com/24466-brown-dwarf-weather-map-revealed.html)

<http://www.space.com/24462-nearest-brown-dwarf-star-shows-moody-atmosphere-video.html>

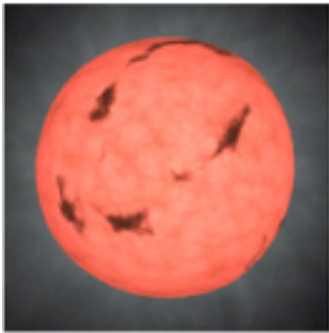
<http://www.space.com/24450-brown-dwarf-photos-misfit-failed-stars.html>

<http://i.space.com/images/i/000/036/488/i02/brown-dwarf-objects-140129a-02.jpg?1391016731>

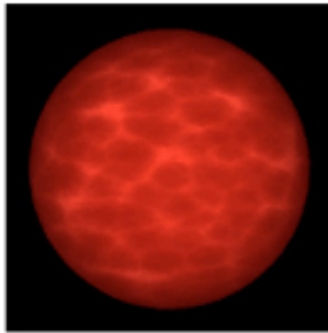
Scientists have created the first weather map of a brown dwarf, revealing a rare glimpse at alien weather patterns on a substar with not enough mass to ever burn hot enough to ignite sustainable fusion as a full-blown star.

The map shows the weather on the surface of WISE J104915.57-531906.1B (called **Luhman 16B** for short), **the nearest brown dwarf to Earth at 6.5 light-years away**. The light and dark features of the failed star's surface have been mapped, using the European Southern Observatory, whose Very Large Telescope in Chile's extremely dry Atacama Desert contributed the needed data.

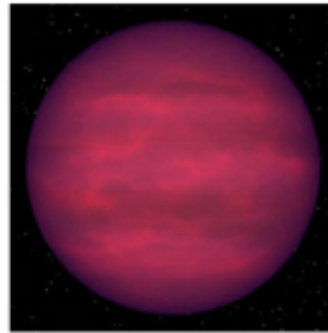
Brown dwarfs are called failed stars because they are larger than gas giant planets like Jupiter, yet still too small to produce nuclear fusion like a true star. Scientists have only found a few hundred of the odd objects, with the first confirmed 20 years ago.



M-class stars are the coolest stars that can burn successfully, and are the most common stars in the universe (about 75 percent of the stars in the sun's neighborhood). Many M-stars are red dwarfs, but some are brown dwarfs.



L-class brown dwarfs are cooler than M stars. Some L stars can support hydrogen fusion, but most do not.



T-class brown dwarfs have surface temperatures in the range of 800 to 1,880 degrees Fahrenheit (430 to 1,030 degrees Celsius). T dwarfs are largely composed of methane.



Y-class brown dwarfs are the coolest of the dwarfs. Their temperature may be as low as that of a household oven, or even the temperature of a human body.

From: <http://i.space.com/images/i/000/036/488/i02/brown-dwarf-objects-140129a-02.jpg?1391016731>

"Previous observations have suggested that brown dwarfs have mottled surfaces, (as to sunspot-pocked stars) but now we can start to directly map them, and what we see is presumably patchy cloud cover, somewhat like what we see on Jupiter.

**Luhman 16B** probably harbors gaseous clouds made of iron and other minerals in a mostly hydrogen atmosphere. This brown dwarf rotates fully about every four hours. [The Sun takes 4 weeks!] Temperatures soar to about 1,100° C (2,000° F)1.

Luhman 16B is one in a pair of brown dwarfs in the southern constellation Vela, the sail. Its brighter counterpart is known as Luhman 16A. Scientists have been able to dissect what is happening in different atmospheric layers on both Luhman 16B and Luhman 16A.

The two were discovered in 2013 using data from NASA's WISE space telescope, which maps the sky in infrared light. Doppler imaging was used to create the Luhman 16B weather map, reminiscent of satellite weather views of Earth. Scientists hope to one day be able to watch cloud patterns form, evolve and dissipate. By examining weather on brown dwarfs, scientists might be able to better understand how the atmospheres of giant planets outside of the solar system work.

The weather patterns on these two brown dwarfs are quite complex and their cloud structure varies quite strongly as a function of atmospheric depth that suggests multiple cloud layers. ##

## INTERSTELLAR TRAVEL?

### Powering a Starship With a Black Hole

<http://www.space.com/24306-interstellar-flight-black-hole-power.html>

January 16, 2014 – Jeff Lee, Researcher for the X-Physics, Propulsion and Power group of the nonprofit research organization [Icarus Interstellar](#), and faculty member of Crescent School, discusses the possibility of a starship powered by black holes.

[Interstellar flight](#) is certainly among the most daunting challenges ever considered by human civilization. The distances to even the closest stars are so stupendous that constructing even a scale model of interstellar distance is impractical. For instance, if on such a model the separation of the Earth and sun is 1 inch (2.5 centimeters), the nearest star to our solar system (Proxima Centauri) would be 4.3 miles (6.9 kilometers) away!

The fastest object ever built by the human species is the Voyager 1 space probe, moving at a speed of **18 miles per second**. If it were heading toward Proxima Centauri (which it is not), Voyager 1 would reach our nearest stellar neighbor in about 80,000 years.

Clearly, if interstellar travel is to be accomplished on human timescales, much greater speeds are required. **At 10 percent of the speed of light** (a thousand times faster than Voyager 1, but a conceivable speed for likely soon-to-be-realized fusion engines), **Proxima Centuri could be reached in approximately 45 years** — less than a human lifetime. The necessary energies to achieve speeds that would get to the stars in such a time frame, are equally mind-boggling.

**Editor:** Read the rest of the article to understand just how far-fetched such goals are. It would seem that the only realistic form of interstellar travel would be to send sub-light speed arks with frozen genetic material that would be carefully thawed and mated and nursed in time for arrival at a star, which the ship has determined to have a life-friendly planet, too young to have nursed native life to the multi-cellular level. Our hypothesis is that life can make interstellar journeys, but not individuals.

### Could Betelgeuse (Alpha Orionis) soon go Supernova?

<http://www.foxnews.com/story/2009/06/11/nearby-star-may-be-getting-ready-to-explode/>



Betelgeuse is in the upper left  The bright Constellation Orion

Its name is Arabic for “the central one” – <http://en.wikipedia.org/wiki/Betelgeuse>

**Bye-bye, Betelgeuse?** The nearby, well-known and very bright star may soon explode in a supernova, according to data released by U.C. Berkeley researchers Tuesday. The red giant Betelgeuse, once so large it would reach out to Jupiter's orbit if placed in our own solar system, has shrunk by 15 percent over the past decade in a half, although it's just as bright as it's ever been.

Red giant stars are thought to have short, complicated and violent lifespans. Lasting at most a few million years, they quickly burn out their hydrogen fuel and then switch to helium, carbon and other elements in a series of partial collapses, refuelings and restarts.

Betelgeuse, which is thought to be reaching the end of its lifespan, may be experiencing one of those collapses as it switches from one element to another as nuclear-fusion fuel. There are still lots of things we don't know about stars, including what happens as red giants near the ends of their lives.

The huge star may become a nesting doll of elements, with a mixed iron–nickel core surrounded by onion–like layers of silicon, oxygen, neon, carbon, helium and hydrogen.

As the iron fuel runs out, it may explode into a supernova, blasting newly created elements out into the universe and leaving behind a small, incredibly dense neutron star.

All the heavier elements in the universe — including all the oxygen, carbon and iron in your own body — were created in such a way. It's possible we're observing the beginning of Betelgeuse's final collapse now. If so, the star, which is 600 light–years away, may already have exploded — and we'll be in for a spectacular, and perfectly safe, interstellar fireworks show in a few hundred years. ##

## THROUGH YOUR TELESCOPE

### Messier Object Sky Wonders – The Virgo Cluster of Galaxies

By Aleksandra Voinea



The Virgo Cluster is a subject of Messier Madness due to many bright galaxies inside it, such as the giant elliptical galaxy Messier 87, situated at the very center of the cluster, or, the brightest, the elliptical galaxy Messier 49.

Structurally speaking, the cluster is a rather heterogeneous mixture of spiral and elliptical galaxies, with elliptical more concentrated than spirals. An aggregate of three sub clumps: Virgo A, centered around M87, a second centered on M86, and Virgo B, that surrounds M49. Of the three, the first sub clump, formed by a mixture of elliptical, lenticular and gas–poor spirals is the dominant one.

The Virgo Cluster extends a great gravitational attraction on the other elements of the Super cluster. The Intercluster medium is the usual hot, rarefied plasma at temperatures of 30 million plus Kelvin. It emits a decent quantity of X–rays, and within it can be found intergalactic stars as well as planetary nebulae or globular clusters. Amongst the possible astrophysical entities, there are dwarf galaxies and star formation regions. ##



## To The Stars International Quarterly Editorial Team



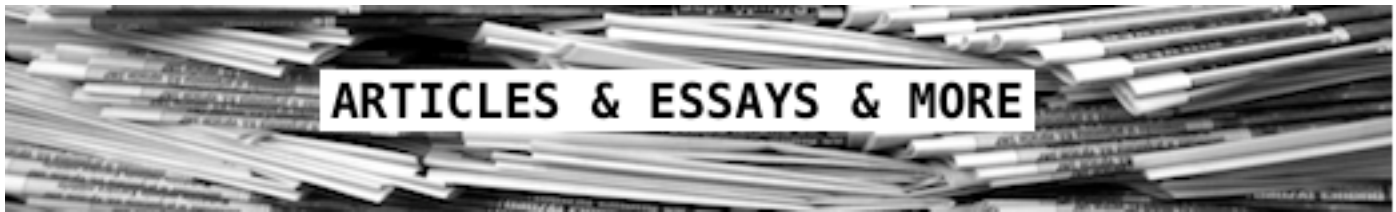
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 The TSSIQ editorial team consists of persons of various backgrounds who are free t

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**As well as for reporters from various nations and student groups**



## “Mother Earth” Implies “Father Sky”

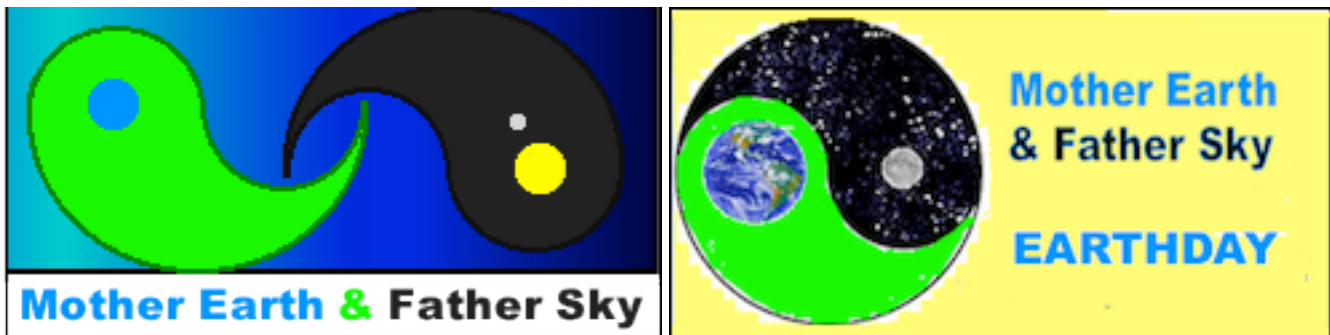
By Peter Kokh

**FACT: “Earth Day”** is an annual event, celebrated on April 22, on which events are held worldwide to demonstrate support for environmental protection. It was first celebrated in the United States in 1970, and is now coordinated globally by the Earth Day Network and celebrated in more than 192 countries each year. For convenience, it is now commonly celebrated on the nearest Saturday. (Wikipedia)

**FACT:** There is a considerable lack of dialog, and little expression of affinity, between “environmentalists” and “space-interested” people and organizations. Indeed, there is some regrettable mutual suspicion.

**FACT: “Mother Earth Implies “Father Sky”** – We need to tweak Earth Day celebrations and observances to get this message out. **“Where would Mother Earth be without the Sun and the Moon?”** We can make that question our door opener. Everyone will see the connection.

**A NEW EXPANDED LOGO:** The “YinYang” symbol – the hallmark of **inseparable complementarity** – is just what we need to get our message across, instantly and instinctively.



### Where would Earth be without the Sun and the Moon?

Now we can talk about ways in which resources from space – and from the Moon – can help us keep Mother Earth healthy. Everyone should accept the help we get in identifying and sizing up Earth’s environmental problems from satellites in orbit above, monitoring deforestation, spreading deserts, loss of ice cover, changing climates, and so on.

Environmentalists and us space resource advocates agree that tapping solar power can ease the demand on carbon-based fuels. But to totally replace those fuels might mean paving over hundreds of thousands of square kilometers/miles (don’t quibble) of real estate and that could be a problem in itself.

We are making progress, however, and the urban green roofs movement helps – every little bit.

Solar Power Satellites in orbit could help immensely, although some will find that “littering the sky” with them will be offensive in itself. Proper design tweaking could help address that threat. And we space nuts are delinquent in not paying attention to that opportunity to reduce objections.

Originally, the idea was to build these very large objects in GeoSynchronous Earth Orbit, GEO, with resources from the Moon, on the grounds that shipment of a given tonnage from the Moon to GEO would require only a 23rd as much fuel as boosting them up from orbit. Others point out that it would cost too much to put such factories on the Moon. Others fear scarring the Moon. Both dangers can be handled.

First we have to junk, once and for all, the habit of throwing away everything we put into space instead of designing each item for some other useful function. NASA’s use once and junk philosophy may be the easiest procedure, but in the long run, it will be seen as a crime against the future, and economics.

Some say factories on the Moon will cost too much. Not if they are built tele-robotically.

The simple compromise of the “MUS/cle” strategy, manufacturing Massive, Unitary, Simple things on the Moon, and bringing up from Earth the complex, lightweight, electronic components is the way.

[http://www.moonsociety.org/publications/mmm\\_papers/muscle\\_paper.htm](http://www.moonsociety.org/publications/mmm_papers/muscle_paper.htm) – MMM #18, Sept. 1988

As to the currently in vogue concept of bringing everything up from Earth to the Moon, that is okay for small demonstration units. But if we will want hundreds, if not more of these, depending on size, we will shoot ourselves in the foot ecologically if this means hundreds, if not thousands of launched from Earth's surface with rockets spewing mega tons of atmosphere polluting exhausts.

We have to look not only at price, and practicality, but at gross ecological effect. "Killing Peter to Pay Paul" has never been a good policy.

### **Lunar Settlements and Environmental Concerns**

Our industrial activities on the Moon need not scar its appearance. First our habitat and working spaces will need to be covered with several yards~meters of moon dust (regolith) for shielding not only from cosmic radiation, but also from thermal extremes of cold and heat. So they will blend in.

Second, gathering moon dust for these and industrial uses, need not scar the Moon the way strip mining for coal has done in many places on Earth (we have seen examples in Pennsylvania) as we would go around craters more than a meters or so wide, skimming off a meter or so of the 2-50 meter deep regolith blanket. You couldn't tell the difference until you were in the final approach to landing on the Moon.

Basalt is one ready to use material we may want a lot of, and that is best quarried from the inside of a lava tube where it is not immixed with other lunar materials.

### **The Environmental Bonus for Earth of Lunar Settlements**

On the Moon, we will have to establish small minibiospheres in which to live.

> That means constant closed loop recycling of air and water.

> That means "living downwind and downstream of ourselves"

> That means if we pollute, we die.

> **That means lunar settlers will learn to live right in a way that we could not ever do here on Earth, because it will never be "that" urgent, "that do or die!"**

The bulk of the things we throw away are paper and plastics, things made of carbon, nitrogen, and other lightweight elements, extremely common here on Earth, but extremely rare on the Moon. Lunans will be recycling those elements and things made from them religiously. They can teach us down here to do likewise. We won't learn those lessons on our own, because we don't have to! The environmental repercussions of acting badly down here are not that urgent, and easily hidden.

Of all the products and exports from the Moon to the rest of humanity here on Earth, such practices and the means of putting them in effect on Earth are perhaps the most important.

Without the Moon, Earth would be rotating in about 10 hours instead of 24. Our tides would be much lower and that might have slowed the evolution of life in tidal pools.

Without the Moon, we would have neither lunar or solar eclipses, and mathematics needed to predict them might have developed more slowly.

Without the Moon, some of our parents might never have been moved to get acquainted.

**AS TO THE SUN:** We don't have to go into that. We just wouldn't be here.

**So, Without the Sun and the Moon, Mother Earth would not be a Mother.**

**It is time for both communities to pay respect to both Yin and Yang**

When we celebrate Mother Earth, we should also honor Father Sky!

It is time for space-interested people to come to the rescue of the Earth so loved by environmentalists. And indeed, by doing so, we will become the ultimate environmentalists. So let's jump on "EarthDay" as our ticket to get across these lessons to the bulk of people who never think of them. And above all, let us use this ticket to not only join the Environmental Movement, but to seize the lead. For we see not just part of the picture but the whole picture.

Indeed, not only have we been derelict in putting the two "embracing halves" together, but so have many "environmentalists"

If Mother Earth and Father Sky are YinYang codependents, then we need to put negative feelings aside in bringing the ProSpace and ProEnvironment Movements together.

There is an old adage used at wedding ceremonies: "What God has put together let no man put asunder." We have our marching orders, bury bad feelings, and make not peace, but love with the "other side." "Earthday," as an annual world-wide observance **is our opportunity to do just that**, and to show that we are **the more "holistic"** in putting Mother Earth and Father Sky together, as they should be. ##

more: <http://www.moonsociety.org/projects/projectteams/enviro-space/index.html>

## The Critical Path to “Pioneering the Moon”

By Peter Kokh

[Previously printed in Moon Miners’ Manifesto #257, August 2012]

### I. The Situation

Currently, some of us in the Moon Society and in the National Space Society are working hard to get more people aboard a path that will break the current log jam – the logs being different visions of our future in space, each with its own set of horse-blinders.

To this end, Board member Al Anzaldúa and I have spent many hours working on a plan to promote priority development of the technologies needed in common to return to the Moon, to mount a manned mission to Mars, and to prospect the asteroids. This is the “**Triway to Space**” plan and Declaration, published in MMM #256 and online, in **Space Review**; <http://www.thespacereview.com/article/2078/1>

Also to this end, a number of us are working with John Strickland of NSS–Austin to mature a **Cis–Lunar Transport Plan** that will better, and more economically work to open the Moon, Mars, and Asteroids.

We all recognize the shortcomings in NASA’s vision and goals, encumbered as they are by the inanities of the political process. But these efforts, as timely and revolutionary as they are, are not enough to those of us who share the core vision of the Moon Society,

“accelerating the day when there will be civilian settlements on the Moon, making use of local resources through private enterprise both to support the pioneers themselves and to help alleviate Earth’s stubborn energy and environmental problems.”

From: [http://www.moonsociety.org/about/vision\\_mission.html](http://www.moonsociety.org/about/vision_mission.html) – a document worth reading in full!

It is not enough to return to the Moon “to stay.” “Stay” to do what? Build an outpost that overtime will be as busy with exploration activities as McMurdo Sound station in Antarctica? Many would settle for that several decades out. Yes we want to fully explore the Moon, deploy telescopes that can better explore the universe, including radio telescopes on the farside – the only place in our solar system where we can be shielded from the growing radio noise cacophony that comes from Earth. Yes to build a fuel production station at one of the Moon’s poles to fuel our ships to go anywhere and do anything, especially to build the “Cis–Lunar Economy.”

But to some of us, that is not enough. Our goal is to extend the human frontier to the “8th continent”, not in the manner in which we have been doing on the 7th continent, Antarctica, but as we have done on the five other “new continents” since humanity’s “Out of Africa” Epic began before our current memories and legends. Our goal is to transform the Moon into a “human world.” Sorry, but fuel stations in the polar icefields, does not quite do that.

The Moon Society is pushing this first opening of course, as it must, as it should. But we should not kid ourselves that our mission stops here.

#### What is needed to “Settle” the Moon

Because of the high cost of imports – even with transports burning liquid oxygen and hydrogen produced from lunar polar ice and brought up to fuel stations at L1 and in Low Earth Orbit – to expand operations on the Moon, we must be able to produce the great mass of items we need to expand our habitats and operations from materials produced on the Moon. In Situ Resource Utilization or ISRU (“on location” for those who do not need to show how erudite we are by using Latin phrases) has to concern itself with more than producing liquid oxygen and liquid hydrogen and drinking water.

We have to learn how to build and manufacture the heaviest in gross mass (number of items times mass each) that we will need – i.e building and manufacturing materials – from the elements in moon dust or regolith. More on that below.

Now anything lunar pioneers make for themselves, can be exported elsewhere “in space” at less cost than similar items made on Earth. Products manufactured on the Moon will furnish space hotels and other stations in Low Earth Orbit, Geosynchronous Earth Orbit and elsewhere in cis–lunar space, earning income for the lunar settlements. Read more: [http://www.moonsociety.org/publications/mmm\\_papers/muscle\\_paper.htm](http://www.moonsociety.org/publications/mmm_papers/muscle_paper.htm)

In the next article, we will discuss what building and manufacturing materials are most realistic and most promising. “ISRU” research has to prioritize those materials if we are serious about making settlements in which pioneers can feel “at home” on the Moon. These materials will also build more outposts used just for science and exploration. So if you are one who feels anything more is unrealistic, you still owe it to yourself to see that these ISRU goals are prioritized.



### Where to live on the Moon:

Most serious (not science–fantasy) habitat/outpost designs circulated through recent decades confine personnel to cramped interiors very much as submarines and sea–floor outposts do. That is tolerable for short tours of duty. Submariners commonly spend six months under water, totally withdrawn from the “world” as they have always known and experienced it.

But if we are talking not just about persons on temporary tours of duty, but about “pioneer settlers” who intend to stick it out long term, and if things go well, live out the rest of their lives on this new world, even raising families, complexes of habitat modules do not do it. Rather, we must learn in various ways, approaching the daunting task from both ends, how to marry our frontier settlements with the barren, airless, radiation–washed Moon itself. And those who can’t see how we could ever do that are part of the problem.

Now many readers may be familiar with Robert A. Heinlein’s classic science fiction novel, “The Moon is a Harsh Mistress.” Heinlein envisioned cities on the Moon, housed in complexes of tunnels carved out of the bedrock. That was the most realistic vision for some time.

Now that we know that the lava sheets of the lunar maria (the dark blotches on the side of the Moon that always faces Earth) must be laced with networks of lava tubes of considerable size, we know that at least in those areas, our “tunnels” are waiting for us. We have now discovered a number of lavatube skylights, and may in time learn how to read surface clues well enough to map some of these networks.

But there are no lavatubes in the highlands, and it is important to keep in mind that both lunar poles are in highland areas. In fact, the closest mare areas to the south pole are 1,400 miles or so to the north (Humorum, Nectaris, Australe, etc.) The north pole is more blessed, with the northern “shore” of Mare Frigoris some 600 miles distant. Now some imagine pressurizing and “terraforming” these vast subsurface tubes, but that again, is a flight of science–fancy. The Moon is rich in oxygen but very, very stingy in Nitrogen, which is the very important buffer gas that makes up 4/5th of Earth’s atmosphere. In short, pressurizing a sub surface lavatube is for now “science fiction” of the “way–off” kind. We will settle lavatubes but in the same general type of pressurized modular structures that we would elsewhere cover with a blanket of moondust out on the surface.

Some envision large cities on the surface, very much like cities on Earth, but protected from the life–squenching lunar environment by immense transparent domes made of “unobtainium.” We say that, because while small domes of a few yards or meters in diameter might work (but fail to protect dwellers from radiation), much larger domes would be blown off the surface by the pressures they were trying to contain. The dome city would work only on a world with an atmosphere not too different than in pressure, from the Earth–like atmosphere inside, but of unbeathable composition. For example on Mars – if Mars atmosphere could be thickened substantially.

But how do we make our settlements any more livable than submarines! That is the challenge, and happily, there are lots of ways to meet that challenge and then some.

### Explorers and scientist are paid. How will Settlers earn their keep?

We’ve already given the major part of the answer: anything settlers make for themselves, big or small, simple or complex, be it building materials, modules, machine parts, – or even food! – they will be able to market in LEO, GEO, stations at L1, and other cis–lunar locations – at a cost advantage over items made or produced on the Earth’s surface. Why? Because it takes only 1/23rd the amount of fuel to ship something “down the gravity well” than “up the gravity well” from Earth’s surface. The Moon’s 1/6th gravity is perhaps its greatest asset. And it will be some time, if ever, before fuel costs are too low to make a difference.

All articles in past issues of Moon Miners’ Manifesto (the first 25 years) which have a direct or indirect bearing on the Lunar Economy have now been released in an MMM Theme Issue: the Lunar Economy, available as a free download PDF file:

[http://www.moonsociety.org/publications/mmm\\_themes/mmm\\_LunarEconomy.pdf](http://www.moonsociety.org/publications/mmm_themes/mmm_LunarEconomy.pdf)

### So How will Pioneers come to “feel at home” on the Moon?

We have pointed out that they must live underground to be shielded from cosmic radiation and solar flares. But this can be in tunnels, lavatubes or out on the surface but covered with a blanket of moondust on the order of 5–6 yards~meters thick. If you stop and think, that is how we on Earth are protected from radiation. Yes, we live under the shield of the Van Allen Belts created by Earth’s strong magnetosphere. But our tick atmosphere protects us as well. If it were to get cold enough here on Earth to freeze the oxygen and nitrogen in the atmosphere, everything would be covered by an “analogous blanket” of nitrogen–oxygen snow!

Now this does not answer question of getting to feel at home, becoming comfortable with the forbidding lunar environment as a friend, not an enemy. That we will take up in the third article.

Note that we have already talked about making building materials and other products out of the elements present in moon dust. That in itself is part of the answer! That the Moon furnishes us with these materials already makes this barren world “friendly!”

## II. Building and Manufacturing Materials from Moon dust

### Glass–Glass Composites

When I launched Moon Miners’ Manifesto, seminal initial experiments with “glass–glass composites” was underway under the aegis of the Space Studies Institute, then headquartered in Princeton, New Jersey. The holy grail was to see if we could produce glass fibers with a high melting point to imbed in a matrix of a glass with a much lower melting point. Experiments funded in part by SSI using lead as a dopant to lower the matrix glass melting point produced promising results. That was in 1937, and not much progress has been made since, for lack of funding. We proposed a business plan that might finance continued experiments that would produce a product marketable here on Earth, with the idea that by the time we got to the Moon, we would have plenty of experience with a close analog of the technology needed on the Moon. We suggested replacing lead (which would have to be imported) with lunar sodium and/or potassium, abundant enough.

[http://www.moonsociety.org/publications/mmm\\_papers/glass\\_composites\\_paper.htm](http://www.moonsociety.org/publications/mmm_papers/glass_composites_paper.htm)

Of course, no one took up on this, and nothing happened. But the feeling was common that glass–glass composites could be used to make many useful things from parts for Solar Power Satellites to lunar homestead furniture and perhaps even pressurizable habitat modules.

### Cast Basalt Products

Meanwhile, some time back I had learned about cast basalt products, such as abrasion–resistant tiles and abrasion–resistant pipes: just what we needed to handle moon dust which is very abrasive. Indeed. It seem so very vital that we launch the first industrial complex on the Moon in a basalt–rich mare area for this very reason, that it seemed to be suicide to start setting up shop at the poles, as important as water and its components may be.

Cast basalt pipes and sluices and other objects needed to handle moon dust in an industrial operation would not be the only prize. Cast basalt could be used for floor and wall tiles, for table tops, for watertight planters needed to begin lunar agriculture, and for much much more. A basalt industry seems essential.

### Lunar Alloys of Iron, Titanium, Aluminum, and Magnesium

These are the four “engineering metals” all present in sufficient abundance in moon dust, iron fines being everywhere, but more abundant in the maria, along with titanium, and with aluminum and magnesium being more abundant in the highlands. The catch is none of these “engineering metals” in pure form is of much use. We have found ways to alloy all of them to improve their performance. The trick is that the preferred alloy ingredients are not handily abundant on the Moon. We have to test “second best” formulations. Some of these have been tried on Earth but never put in production because we had better alternatives.

My #1 Brainstorming side–kick for some twelve years now, has been Dave Dietzler, of Moon Society St. Louis. Not afraid to go down a blind alley, Dave has found some promising options, such as “maraging steel” and these have been the subject of several recent articles.

### Basalt fiber products

Meanwhile, I had stumbled on an article about about a basalt fiber industry in Northwestern India (Gujarat State, if I remember correctly) and between Dave and I we are learning what a motherlode jackpot of technology this is. Rebar, used to strengthen concrete can no longer compete with “rockbar” made out of basalt fibers. The latter are water resistant (won’t rust), stress resistant, less subject to thermal expansion and contraction.

We are now wondering what else this new wonder material could be used for: rails for lunar trains? Shells of habitat modules? Basalt is a simple material abundant in the lunar maria, which can be put to a host of uses: parts for Solar Power arrays included. In contrast, no lunar–glass or lunar–metal alloy seems as “ready to hit the market” as cast basalt and basalt fiber products. Just don’t look for basalt anywhere near the lunar poles! **So here is where ISRU should concentrate: in the Moon’s maria.** Note: If we dig trenches to inset our modules, the basalt at the bottom of the trench will be more concentrated.

Basalt fibers could be used to make “sandbags” for deploying moon dust over a habitat in a “removable manner. It could make tarps and matts and so much more.

At any rate, beyond oxygen production, development of **easily produced and widely useful lunar building and manufacturing materials must have priority** – priority now, not a decade after we return. Cast basalt, glass composite, lunar producible alloys all need attention that they have not been getting. This is what we must mean by “ISRU.” What we now mean by it makes the users of this “secret code” term look shortsighted.

As we suggested in the Glass–Glass Composites paper referenced above, the place to start, with further development of the potential of basalt fiber, for example, is to find as yet unexplored but potentially profitable terrestrial uses, and then develop new products accordingly. The result is a process we have called **“spin-up” (as opposed to “spin-off”) – putting a close analog of a technology we will need on the Moon, “on the shelf” ready to use when we get there.** Some could get rich doing this!

### **III. Incorporating an Earth–like “Outdoors” in Middoor Spaces**

#### **A Eureka Moment**

Moon Miners’ Manifesto saw the light of day in December 1986 only because of a “Eureka Moment” I had experienced a year and a half earlier in May 1985. You can/should (if you want to understand) read about this in [http://www.moonsociety.org/chapters/milwaukee/mmm/mmm\\_1.html](http://www.moonsociety.org/chapters/milwaukee/mmm/mmm_1.html)

In short, a visit to a most unique and original underground home 30–some kilometers (20–some miles) NW of Milwaukee convinced me, that though, as Heinlein predicted, we might have to borrow into the Moon to live safely, we could “bring the views and the sunshine down with us.” While we had to be tucked under a moondust blanket one way or the other, that did not mean a disconnect with the best that the lunar surface has to offer: views of the landscape, and sunshine. Sunshine suggested house plants and vegetation–refreshed air, as well as food. Someone will undoubtedly reengineer my “Z-view” periscopic windows and other features, but they are too superior to a TV screen to ignore.

#### **Beyond a network of “indoors only” habitat and activity modules**

The first starter outposts will be but a complex of modules some inline, other off T and X junctions. But eventually hallway and even pressurized “street networks” will arise. And with that comes opportunity. Even individual modules can have “house plants” and “living walls” (Wikipedia “Green Walls”) to refresh the air and assist in treating toilet wastes. If a modular biospherics plan is adopted to mate with modular architectures, then the capacity to refresh water and air will grow apace with the complex proper, minimizing what part of these processes has to be taken care of by central facilities. Halls can be lined with plants in the form of living walls, for example, and such “walls” can also serve as room dividers.

When the settlement complex grow to the point that travel from one part to the other makes electric vehicles most welcome, then “streets” will emerge. These too can contribute to the biomass needed to sustain a self–refreshing atmosphere. While “room temperature” will be maintained in habitat and activity modules, there is no reason not to let temperatures vary – within reason – as the 14.75 day long dayspan with continual sunshine passes and then rotates with the equally long nightspan.

The result is that we have a buffer, temperature– and climate–wise between the “indoors” and the “out–vac”, the “middoors” – an environment more reminiscent of the outdoors back on Earth. Forget about Heinlein’s groundhog tunnels! Then if vehicles dock with outpost and settlement docks, so that passage between without spacesuits is possible, we have the start of a “virtual” global lunar pressurized “Earthlike” environment.

### **IV. The Role of Indigenous Arts & Crafts**

#### **The need for people everywhere to express themselves with local materials**

Every time pioneers on Earth have left their familiar home country and ventured into places with different sets of easily available materials and plants and animals, they began to feel more and more at home as they learned to build and adorn their homes out of things locally available. It will be no different on the Moon. Objects of cast and hewn and carved basalt will be an early choice in much of the Moon’s nearside. But artists also have a keen eye for the hidden possibilities within every bit of “free” material including scavengable scrap and “junk.”

We have personally attempted to pioneer an analog of a lunar painting medium.

[http://www.moonsociety.org/chapters/milwaukee/painting\\_exp.html](http://www.moonsociety.org/chapters/milwaukee/painting_exp.html)

The pioneers will find things and materials to turn into art and furnishings. Hand made or crafted objects in front of a window or on the surface outside will temper the lifeless and life–squelching lunar surface with things made by human hands. Slowly, both from inside and outside, human spaces and settlements will begin to belong to the moonscapes, and vice versa.

## V. The Role of “Lee-Vac” and “Out-Vac” Activities

### Outside Sports and Hobbies

We’ve all seen paintings of lunar pioneers playing golf on the lunar surface. Some pioneers will love to go foraging for moon rocks that look special, or are of a carvable kind. Other will just like to stroll form time to time in the vast black-skyed outdoors – the “out-vac” (yes, after Australia’s “outback.”) There will be road rallies. As space suits become lighter and permit more movement, more types of outdoor activities will emerge.

But there is an intermediate environment, the “lee-vac” – moon dust shielded but unpressurized hangers and domes and stadiums where lighter suits can be worn because neither radiation nor extreme heat nor extreme cold are a problem. In such lee-vac spaces, pioneers can attempt a lot of things in lunar gravity, in lunar vacuum, without the drawbacks of full-exposure.

Bit by bit, pioneers will adapt to this seemingly hostile world. No place is hostile if you know how to deal with it. Consider for example, how the Inuit and Samoyeds have adapted to the extreme exposed coastlands of the Russian, Alaskan, Canadian, Greenland coasts. If we did not know about them, we would have thought such adaptation would be impossible. But it wasn’t, was it. Neither will it be on the Moon. Come back in a century or so and you will find a frontier population as happy and settled in as most of us are here on Earth.

## VI Conclusion

### A Contrast of Visions: “horse-blinded” verses “eyes wide open”

Perhaps most persons interested in opening the Moon only see small isolated outposts where persons clearly out of their element will do their best to put up with unearthly conditions for a tour of duty or two. The vision we have sketched of a quite more developed and satisfying frontier may seem science-fiction/fantasy to many, but this vision is grounded not only in the realities of the Moon and its features and makeup, but also in the capacities and drives that are characteristic of human pioneers. Were it not so, we’d still be found only in Africa.

The human epic has been an “intercontinental” one. The Moon is another kind of continent (as big as Africa and Australia together) across another kind of sea. This final “intercontinental” colonization will also be the inaugural “interplanetary” one. Do not judge the possibilities from the challenges new lands confront us with. Judge the possibilities from the unlimited capabilities to adapt which are part of the human makeup. We should never doubt that we have it in us. Those who would have us “stay home on Earth” are of the same ilk as those who would not dare leave Africa.

And this is just the beginning.

To correct Genesis if I dare, **“Of stardust thou art, and to the Stars thou shalt return.”**

We owe it to the Creative Agency behind our existence to realize all the capacities built into us. Not to do so would be the ultimate sin.

PK



### Further Recommended Reading

#### (Selected) MMM Papers

[http://www.moonsociety.org/publications/mmm\\_papers/muscle\\_paper.htm](http://www.moonsociety.org/publications/mmm_papers/muscle_paper.htm)

[http://www.moonsociety.org/publications/mmm\\_papers/outpost\\_trap.html](http://www.moonsociety.org/publications/mmm_papers/outpost_trap.html)

[http://www.moonsociety.org/publications/mmm\\_papers/beyond\\_moonbase\\_1.pdf](http://www.moonsociety.org/publications/mmm_papers/beyond_moonbase_1.pdf)

[http://www.moonsociety.org/publications/mmm\\_papers/pioneer-mental-health.html](http://www.moonsociety.org/publications/mmm_papers/pioneer-mental-health.html)

#### (Selected) MMM Theme issues

[http://www.moonsociety.org/publications/mmm\\_themes/mmmt\\_EdenOnLuna.pdf](http://www.moonsociety.org/publications/mmm_themes/mmmt_EdenOnLuna.pdf)

[http://www.moonsociety.org/publications/mmm\\_themes/mmmt\\_ArtsCrafts.pdf](http://www.moonsociety.org/publications/mmm_themes/mmmt_ArtsCrafts.pdf)

[http://www.moonsociety.org/publications/mmm\\_themes/mmmt\\_LunarEconomy.pdf](http://www.moonsociety.org/publications/mmm_themes/mmmt_LunarEconomy.pdf)



## Backing Up” our “Civilization”

By Peter Kokh

### Backing up Knowledge

Many, if not most of us, have learned the hard way, how important it is to backup our computer files. One unpredictable hard drive crash, or even a misplaced key stroke, could wipe out everything into which we have put so many hours of work, if we had not found a way to duplicate our files in safer modes.

And it is not only electronic mishaps to fear. Apple, for example, has the notorious mercenary habit of coming out with new software that will not read old files. (There ought to be a law against that!)

We can store files on Google, and/or in electronic “clouds.” But a serious enough solar electronic storm could erase all that. Before the computer age, we had books. Yes, books can burn, or rot, but the chances of that are slim compared to the chances of electronic disasters. And you did not have to keep paying rent to libraries to keep books on their shelves. Our new information system is strictly for profit. Fail to renew a domain name, on top of a computer crash, and valuable files are lost. More, because we have to pay for storage, many older files are removed from the web as no longer up to date. Try to look something up from a few years back? Good luck!

### Backing up artifacts

Museums, thank heavens, have not yet gone “electronic” or virtual. We need to have a serious national and global conversation of providing the same preservation automatically in case of super solar flares that could erase all electronic files.

### Living Species

Biologists are still discovering previously unknown or uncatalogued species found in remote areas, such as forests, swamps, ocean beds and other places not yet fully explored. Meanwhile, many species are becoming extinct through the spread of civilization into their areas. Forests have been shrinking. Efforts to catalog living species before they are creatures of the past should have greater priority, and by that, we mean greater funding.

Climate change, whether manmade, natural, or more likely some combination of both, is drastically affecting some biomes. A recent survey showed that trees and plants once common in the area surrounding Winnipeg, Manitoba, have, in the past thirty years, been replaced by plants and trees common around Minneapolis, 500 kilometers (300 miles) to the south. This year, melting ice on Baffin Island in the Canadian Arctic have exposed dead moss beds that have been buried under ice for 44,000 years.

Unfortunately, decisions made for political reasons put little priority on funding the cataloging of flora and fauna and organisms in general that are threatened. We think of “our kids” when it comes to money, but not when it comes to passing on the heritage of nature, which leads one to wonder if our “children” have anything to do with stances on either.

### Longer Range Threats

In addition to possible super solar flares, the likes of which have not been felt, or noticed, in historical times, there are other risks: “Super volcanos” being much more likely than super flares or super asteroid strikes. Yellowstone, to judge from past eruptions 700,000 years apart, is overdue. The last eruption left meters of ash covering nearly two thirds of the United States. One within the past 100,000 years in Sumatra, may have reduced Earth’s population at the time to a fraction of what it had been.

And, yes, should a civilization erasing non-detourable asteroid come our way: we owe to our ancestors, and to our offspring, to “back up our civilization“ off planet.”

### Safety for specimens, artifacts, and records

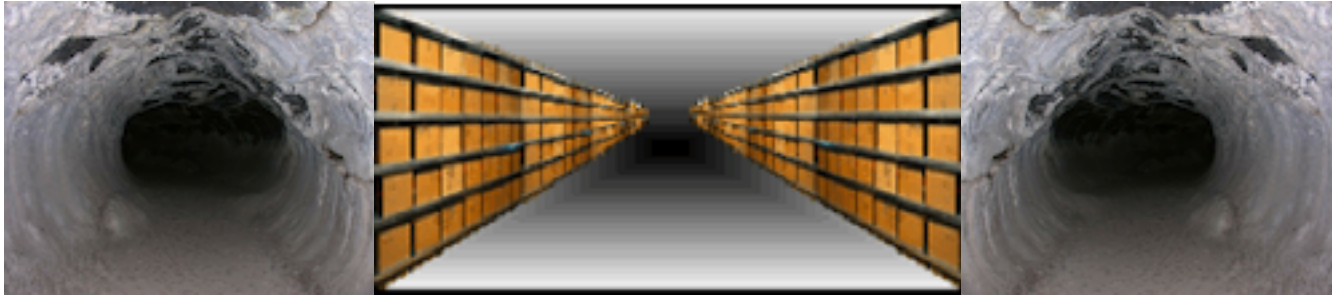
No place on Earth provides a safe depository long range. Earth’s active geology wipes out mountain ranges, valleys, coastlines, and caves. Sure some places may be safe for a hundred thousand years or more, but we want to talk about long term: millions of years, hundreds of millions of years, even longer. We are not thinking now of preservation for far future human generations, although we should, but of “backing up our civilization” so that should, someday, a star-faring civilization come this way, long after our civilization and its ruins have turned to dust, can discover who we were, how we lived, what we were about. Where could we put archives of all kinds so that they could survive our civilization and possibly be discovered by others?

### Lavatubes on the Moon, and Mars

The Moon is geologically dead. The mare areas (dark level plains) on the Moon were formed between 3.5 and 3.8 billion years ago by spreading low-viscosity lava flowing in rivers that crusted over, forming tubes. The tubes still intact have survived that long, formed in an age when life on Earth may still have been one-celled. Here in carefully chosen tubes, unlikely to be compromised over hundreds, even billions of years, we could put the Grand Archives of All Humanity and Earth Life: records of our civilization and cultures; artifacts, preserved biological specimens, or models thereof.

Read “Archive Luna” pp. 19–20 in MMM Classics #11

Should “anyone” come this way, perhaps long after all trace of our civilization had disappeared on our ever changing planet, it is in lunar lavatubes that they would look. Would we leave clues as to which tube to explore? Clues that would survive the ravages of time? Beacons activated by vehicle approach? Could we rig something that would work long after we are gone? It’s worth thinking about.



What about similar archives for the eons in lavatubes on Mars? Mars may not be as geologically dead as the Moon, but why not? Should the Sun have swollen and gotten hotter, making Earth and its Moon more challenging places to visit, a “backup” on Mars might be a good idea. Carrying this idea even further, Voyager 1 photographed lava plains on Neptune’s largest moon, Triton. There may well be ancient lavatubes on that moon. There are no known plans to visit the Neptune system in the near future.

### Flipping the Coin

Yes, some civilization could send scouts our way some time in the distant future (if they had not already done so long ago). The longer the stretch of time we consider, the less unlikely the visit.

But our Sun is young compared to the Galaxy at large: 4.5 billion compared to 8–12 billion years. **Civilizations elsewhere could have preceded ours and even visited our system while life on Earth was still in a more primitive stage.** If so, where might they have left a calling card? **There is one clear answer: in a lunar lavatube that we would not get around to exploring until we were mature enough to handle and digest what we found.**

### Looking at it from another angle

Personally, I am not a believer in FTL, Faster Than Light travel. I see it as a contradiction in terms. But there are other ways to travel between the stars. “Generation Ships” can take their time. After countless generations of living their whole lives in such an “ark” no matter how large, any descendant is not going to want to disembark onto an open to the heavens world that from their ingrained point of view is “inside out” with ever disappearing horizons. They would have “an inside out form of vertigo.”

Now seed ships, carrying genetic material only, to be combined (sperm and eggs into embryos) and raised and then educated by nanny-robots once the ship finds an inhabitable world not already home to a sentient species – now, that’s something else. No living humans would be lost among the stars en route.

Be that as it may, let’s suppose some distant day that a ship of humans arrives in the Alpha Centauri System, a system a billion and a half years older than ours, and find a planet that evidently had life, and from the evidence of non-perishable items in junk piles, had intelligent life. But those people, whoever they were, did not leave records or any other evidence about themselves, their history, their culture, their achievements. Would’t it be nice if they had a moon like ours or some other world in their system that had places like lavatubes that would not be eradicated by weather or geology, and where they had left records there about themselves, their biology, history, and culture?

**Do onto others what you would have them do onto you,** goes the old adage. We should create records and other evidence about ourselves, our world, our culture, our civilization. We have the ideal place, nearby and immune to the ravages of time: lavatubes on the Moon.

### Backing up our Civilization

By this we are talking about a number of things: near term things we are failing to do now, with our switch to “rented” electronic storage, not yet developing storage media immune to solar storms, much less economics, etc. But we need to leave a record not only of our science, our art, our culture, our beliefs, but also of the biologically rich and diverse environment that supports us. Even if the Moon had nothing of resources worth taping, even if it did not offer us a perch from which to expand further into space, we ought to be going to the Moon for something in the long term, more important: “backing up our Civilization,” our culture, our history, and the Living Complex of plant, animal, microbial life in which we live. Is there enough space in those tubes? There must be many thousands of kilometers of intact tubes, a hundred or more meters wide. And more in lava flow layers below. Yes, there is plenty of room.

**If for no other reason than to “Back up” our Civilization,  
We must go into space, and to the Moon in particular.  
We must become a space-faring species.**

**And as a hedge, we should duplicate these Lunar archives in a secure lavatube complex on Mars. PK**

### The Moon? “Been there, done that!” — Not!!

By Peter Kokh – reprinted from MMM #108, September 1997

That the media and a poorly educated public should take the view that “we’ve done the Moon, now let’s move on” is understandable if discouraging. That one hears the same sentiment echoed by many space advocates is much more of a problem.

Perhaps any/everyone’s estimate of “what needs to be done next” is colored more by the drumbeat to which they march than by cool, clear, hard reasoning. Turn of the century American philosopher William James showed in great depth just how much temperament predisposes “reason”. Without attempting to be exhaustive, a first effort to list some of the different siren call drums we space-interested “hear” might be: Explorer, Tourist, Settler, Businessman.

Myself, I have an ear for all of these drums, each of them raising a surge in my spirits. But it would be dishonest of me not to admit that my spiritual home base is as settler. The great variety of topics about which we have written in MMM over these last eleven (now 27) years are testimony enough to that.

Others do not hear that drum so clearly, or it raises much lower tides in their spirits. Unsuspecting just how much remains to be discovered and wondered at on the Moon, the explorers and tourists among us, will naturally want to move on. Some would-be settlers, and many businessmen will want to consolidate our toehold on the Moon first, pointing out the greater logistic base such development will afford for further deeper exploration of the rest of the Solar System.

It is always useless to argue against temperament. The universe is vast and it needs all of us. We must be wise enough to admit that and respect one another. I understand the lure of Mars, of Europa, of Titan. I too would be a Martian, a European, a Titanite.

That said, it must be pointed out that in any non-superficial sense, **we have yet to do the Moon!**

**We did not get enough rocks and dust!** Our samples from six scattered areas, a college effort, are far from representative enough. Nor are they enough in total quantity. Enough perhaps to let us uncover “**what the Moon is made of,**” but orders of magnitude too little to let us discover “**what we can make out of what the Moon is made of.**” That deficiency has set NASA up as high priest over the samples, hoarding them so tightly, lest we never go back for more, that we are prevented from learning what we need to know to give us confidence that we can return to stay, self-sufficiently.

We are forced to rely solely on ivory tower “research” too heavily based on crucially inadequate simulants. That in turn slows us down in developing a viable suite of feasible and serviceable lunar-derived building materials and alloys.

We have explored none of the literally thousands of linear miles of lavatubes which geological clues and photographic tell-tale signs give us a very high level of confidence that we’ll find – cosmic weather sheltered, dust-free hidden valleys many thousands of square miles in aggregate area. We have sampled no central peaks (composed of upthrust mantle material), no polar permashade “cold hole” ice fields, no unflooded great impact basins (the farside thalassoids). We still do not know enough to piece together the real origin of the Moon, the presently in vogue Velikhovskyesque scenario notwithstanding.

We have yet to take advantage of the unique platform the Moon offers optic and radio astronomy both – vantage points of which the Hubble people can only dream. We have yet to visit to the “Peek-a-boos,” lands of the lunar limb, much less explore the first hectare of the lunar farside except from orbit.

The Moon is a gift we’ve “anticipointedly” unwrapped and discarded in a boredom revealing not the Moon’s shallowness, but our own lack of depth, after playing with it for just a few moments. But after all, back then our mindset was “moonandback” one word.

**QUESTION:** Can those so easily and quickly bored with the Moon, totally unable to imagine beneath and beyond appearances, quite incapable of recognizing opportunities staring us in the face, be trusted to be any more insightful when they lead us to Mars?

Or – might we need new leaders, with proven track records in uncovering real possibilities and opportunities for “**reclamation**”, i.e., for “finding resourceful ways to take ‘a barren wasteland’ and turn into a fruitful, productive oasis in which transplanted humans can take root, thrive, and pursue happiness.” How many of these “been-there-done-that people” have wasteland reclamation experience, or even reclamation brainstorming, in their resumes? These very same people will find on Mars, alas, only more “rocks and dust”, more endless expanses of “boring,” not-quite-as-hyped scenery, “unrelieved” frigid cold, and – and this is the bottom line – “no reason to return”.

What we are sure to get out of entrusting them with our leadership is another long “40 years wandering in the desert (of incapacity to imagine)” post-Apollo like retreat before these same people or their intellectual successors succeed in getting significant press for their “on to Europa” fad-charge.

In comparison to the general public, the space-disinterested, WE space-interested people are supposedly extra-imaginative, extra-creative, extra-resourceful, extra-attentive to hidden opportunities and possibilities. Guess what, folks? Not!!! **PK**

## Passing from Outpost to Settlement: The Tell-tale Signals of Passage

By Peter Kokh

Reprinted from MMM #178, September 2004

We all realize that a tentative, toe-in-the-water (or regolith!) base/outpost/beachhead must come first before real settlement can begin. Some believe that there will be a public policy decision to go for “the next stage.” But the transition could come by itself, in many seemingly minor changes of procedure and policy. The baby does not become an adult overnight, after all. Here are some of the things that will give us a clue that the process is underway.

- **Operations transition** from “mission-driven construction & exploration” to outpost growth and development
- **Rigorous sterilization and quarantine procedures are abandoned** as unnecessary ritual
- **Operations slowly transition from “by the book” to experimental pragmatism** -- individual initiative is allowed, then encouraged, in experimentation with processing, manufacturing, even with arts and crafts using local materials to give the outpost a “down home” facelift.
- **Crew members are given permission to go outside alone**
- **Deaths occur from natural causes, and burial** (of the body or cremains) **is permitted**
- **Crew members are permitted to “re-up” indefinitely**, giving them “vested rights” so to speak
- **Relationships between crew members are tacitly accepted**, even if official policy is unchanged.
- **Permission for pregnancy is given after the fact** and the pregnant crew member is allowed to carry the fetus to term without having to return to Earth.
- **Someone “retires” from official duties, but is allowed to remain on location** and tinker to his/her hearivatt’s delight (e.g. starting up a cottage industry)

We welcome your suggestions to other “subtle” clues that the transition is underway. Such a shift in gears may not be planned. It will happen on its own, in due course.

### Anecdotal Signs

- The first private enterprises: (garden, rock, moondust-based; services of all sorts; products for export, repurposing salvage, etc.
- The first 1/6th g Lunar Sports develop beyond the experimental stage
- The first Lunar Soap Opera broadcast to Earth

It is fun to list things that will proclaim that the outpost beachhead “has arrived.” These things will come in time. But we are looking for the subtle first signs.

**Critical Mass** – The indications that the outpost-in-transition has become a settlement with “critical mass” to support “ignition” such as population size, diversity of factories, tools, vehicles, talent pool, reserves, etc. and the amount of vital needs and supplies in storage is another question. Here we are just looking for those first easy to miss clues that a historic phase shift has begun. < MMM >



## The Concept of “Reclamation” of/on the Moon

By Peter Kokh

In the fall of 1986, a group of local space enthusiasts gathered in Milwaukee, Wisconsin, a major port on Lake Michigan. We had decided to form a local chapter of the L5 Society, soon to merge with the National Space Institute (I was already a member of both) to form the National Space Society. After we picked our first officers (I had volunteered to do a newsletter) we started discussing names for the chapter. Most of us happened to be “Moon-focused,” and two names came up. “Milwaukee Moon Miners” was one suggestion, “Lunar Reclamation Society” another. I suggested we use both. And so “Moon Miners’ Manifesto” was adopted as the name of our newsletter, and “Milwaukee Lunar Reclamation Society” as the name of our chapter.

**“Reclamation?”** No, not **“reclaiming the Moon!”** The two words have very different meanings.

**Reclamation is the process of restoring ‘wasteland’ to useful purposes.** The Dutch Polders are perhaps the iconic prime example. By use of an enclosing dam and windmills to pump out the ponded water, large areas were “reclaimed” from the sea, ready for farming and settlement.

**If you look up “reclamation” in a dictionary, you will find something like this:**

1. The conversion of wasteland into land suitable for use of habitation or cultivation
2. The reclaiming of desert, marshy, or submerged areas or other wasteland for farming or other use.
3. The attempt to make land suitable for building or farming:
4. The process of getting something useful from waste, or something previously thought of as waste.

We mentioned the “Poldera” in the Netherlands. Turning to the dictionary again, we find:

“A **polder** is a low-lying tract of land enclosed by man-made embankments (barriers) known as dikes that forms an artificial hydrological entity, meaning it has no connection with outside water other than through manually operated devices. There are three types of polder:

- Land reclaimed from a body of water, such as a lake or the sea bed
- Flood plains separated from the sea or river by a dike
- Marshes separated from the surrounding water by a dike and subsequently drained
- A tract of low land (as in the Netherlands) reclaimed from a body of water (the shallow Zuider Sea).

**Reclamation then, is the essential function of any settlement on the Moon, Mars, or any other body that does not have breathable air and farmable soil.**

MMM went on to develop the concept of the “**Middoors**” pressurized areas that held the bulk of a settlement’s biosphere – plants, crops, trees – in which areas temperatures could vary “seasonally” according to a chosen climate and crop suites. In contrast, “**indoor**” spaces” consist of residences, shops, factories, schools, etc. As to what is “outside” of this containment, we dubbed that the “**out-vac**” – taking a cue from the Australian “out back” – the barren landscapes of the Moon exposed to space.

Thus the concept of “Reclamation” underpins the whole vision of how humans could come to make themselves at home and comfortable on what otherwise is a barren, sterile, “life-squelching” world.

Readers are encouraged to explore the various MMM “Theme” issues, collections of articles from past issues of MMM (now in its 28th year of publication) according to theme. These are free downloads in pdf format. You will find them at [www.moonsociety.org/publications/mmm\\_themes/](http://www.moonsociety.org/publications/mmm_themes/) – this repository is scheduled to be duplicated at [www.nss.org/](http://www.nss.org/) – the specific address to be determined.

## The “Affording Mars Workshop”: background and recommendations

Report and Commentary by Peter Kokh

A recent report on “The Affording Mars Workshop” by Harley A. Thronson and Chris Carberry – Monday, March 3, 2014, appeared in Space Review – <http://www.thespacereview.com/article/2463/1>

*“By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth.*

*And a landing on Mars will follow.”* – President Barack Obama, April 15, 2010.

**Editor:** First, we wish to acknowledge the efforts of Chris Carberry and ExploreMars.org for finding innovative ways to advance the cause of manned Mars exploration. We will not summarize the above article, already a summary. We leave it to TTSIQ readers to read the article. linked to above. Rather, what follows are our own thoughts.

The goal of this workshop seems to accept a timeline, based on “Affordability and Sustainability” with a budget that accounted for inflation.

A workshop with representatives from the commercial space industry on how we can reach the goal of landing humans on Mars in just ten years, with the same annual budget, if not less, would be more welcome. Why? Because it would be more challenging, forcing us to look at new technologies, and keep within budget. It is far more likely that a consortium of space powers would stick to a 10-years-out goal, than to a 20-years-out goal, the latter, by its very leisurely pace, inviting abandonment.

Elon Musk (EBay, Tesla, Space-x), for example, is very interested in a humans to Mars program, and he has amply demonstrated

**the ability of commercial companies to totally outthink bureaucracies funded by governments and in the process produce superior results for less money.**

That said, the “Mars One” “Reality Show” plan to send people to Mars on one way trips in order to begin settlement, although, in the long run, if carefully planned, could be much more successful, does not seem to have more than artwork, without the technical capacity, and with a very simplistic idea of what it would take for such a start to sustain itself.

In the long run, the goal of human “exploration” of Mars is as sure to become a premature dead-end as was Apollo. We need to brainstorm not only “how to get to Mars-and-back,” but “how to get-to-Mars-and-stay.” Settlers will do far more extensive exploration than will a few visitors. But no one should apply who does not realize that because Mars looks like a desert, doesn’t mean it is warm.

Settler wannabees should be forced to live in one of Antarctica’s Dry Valleys for a year or more first. The climate is similar. But Antarctica is not washed with cosmic rays, has fresh breathable air, abundant water, and its surrounding ocean is teeming with life.

**If you can’t handle Antarctica’s Dry Valleys you surely will not be able to handle Mars.**

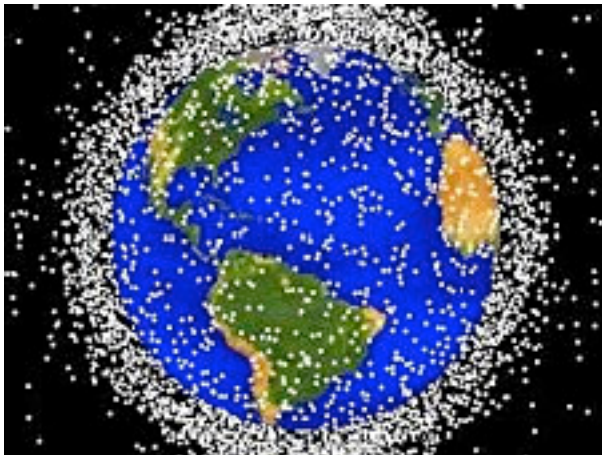
We have not noted a rush of volunteers to do just that. And in that light, that there are so many volunteers becomes meaningless. On the contrary, we have noted with amusement a number of Mars settler wannabes who have made life-style decisions to migrate from colder climate areas of the US and Canada to the warm US southwest. ##

## Detecting an “Adolescent” Civilization around another star by its “Obrutosphere”

By Peter Kokh

<http://news.sciencemag.org/biology/2014/03/scienceshot-new-tool-could-help-spot-alien-life>

<http://www.space.com/25033-rocky-planet-atmosphere-models.html>



“Obrutosphere” i.e. Debris Sphere – we are a long way from finding a full set of ways to remediate the debris problem which is likely to get far worse before the several half-measures (each of which tackles a part of the problem) begin to make a dent. The unspoken risk is that we will end up imprisoning ourselves on our home planet, taking chances only with unmanned satellite and probe launches, concentrating on microsats and microlaunches which have a greater chance of getting through. ##

## Orbital Debris: Resource Ladder to the Stars

By Al Anzaldúa

By now, especially after the recent movie, Gravity, nearly everyone with an interest in outer space has become aware of our orbital debris crisis. According to NASA, there are over 21,000 Earth-orbiting objects larger than a baseball (10 cm) and 500,000 objects between 1 and 10 cm.

The number of particles smaller than 1 cm exceeds 100 million.<sup>1</sup> This orbiting debris consists of dead satellites and other derelict spacecraft, upper stages of launch vehicles, solid rocket motor effluents, flecks of paint, debris from explosions or collisions – even a glove and toothbrush. The debris is an ever-growing hazard to the International Space Station, future space flights, and 1,134 operational satellites.

Although most of the debris is in Low Earth Orbit (LEO), there is a considerable amount in Medium Earth Orbit (MEO) and Geosynchronous Orbit (GSO).<sup>2</sup> Within two LEO altitude bands, 900 to 1000 km (620 miles) and 1,500 km (930 mi), the density for the initiation of the “Kessler Syndrome,”<sup>3</sup> a cascading chain reaction of collisions leading to uncontrollable growth of debris, may have already been reached.<sup>4</sup> Prior to 2007, the principal source of debris was from explosions of old launch vehicle upper stages left with residual propellants and high pressure fluids. China, however, in 2007 intentionally destroyed its Fengyun-1C weather satellite, and in 2009 a non-functioning Russian Cosmos 2251 satellite collided with an U.S. Iridium 33 satellite. One-third of all space debris can be traced to just these two collisions.

The satellite industry is already taking tentative steps to at least not create more debris. For instance, some upper rocket stages now automatically release residual propellants to prevent on-orbit explosions. Still more could be theoretically done in this connection, however, as described below. Unfortunately, there exists no international treaty or authority that can mandate such interventions or technologies, and even with such, orbital debris congestion would remain perilous to working satellites and other spacecraft for the foreseeable future.

### **What is at stake?**

Satellites are intimately involved with our everyday lives. Anyone using Google maps, checking the weather forecast, watching TV, listening to the radio, flying on a plane, using an ATM while traveling, accessing certain Internet sites, taking a cruise, or calling on a cell phone – makes use of satellite technology. All these modern conveniences are being threatened by orbiting space debris. To put it another way, orbiting debris is threatening the very fabric of modern life.

Even future technologies are threatened. For example, Space Based Solar Power (SBSP), an energy technology with enormous potential to improve lives, is also at stake. In 2009, astrophysicist Donald Kessler stated, “large structures such as those considered ... for building solar power stations in Earth orbit could set up a situation where a single satellite failure ... could lead to cascading failures of many satellites.”<sup>5</sup>

### **Pay Now or Pay (Much More) Later**

By now we have seen that all persons living and companies operating in industrialized societies are stakeholders in having unthreatened, long-functioning satellites and other spacecraft in orbit. Therefore, all stakeholders in the short-term will likely have to pay the tab one way or another, perhaps through increased user-fees. On the other hand, if no action is taken until there are exponentially growing multi-level Kessler cascades, the tab will be much higher in terms direct financial costs for insurance and satellite replacement and the negative impact of service disruption on various industries and businesses, to speak nothing of the negative impact on our modern way of life.

The good news is that by remedying the orbital debris situation soon, savings and new wealth can be generated, while the cis-lunar econosphere expands. The first steps can be taken now to create a sustainable solar system infrastructure, new space enterprises, and sustainable outposts throughout our solar system -- and eventually beyond. How this could all possibly be done will be described below.

### **The Satellite Scenario**<sup>6</sup>

It is helpful to review the satellites, services, and industries threatened by orbital debris. Just in LEO there are 554 satellites, providing mostly communication (voice, data, and messaging) services over global regions. Examples include Motorola’s Iridium constellation of 66 satellites orbiting at an altitude of about 781 km, 44 Orbcomm satellites operating at 775 km, and 52 Globalstar satellites at 1440 km. Also in this group are several polar-orbiting weather satellites at 850 km and an unknown number of spy satellites.

Above them in MEO are 87 satellites used for navigation, polar communication, and geodetic/space environment science. Included in this group are 64 U.S. Global Positioning System (GPS) satellites orbiting at 20, 200 km, 24 Russian Glosnass satellites at 19,100 km, 14 Chinese COMPASS satellites at 21,150 km, and 4 European Galileo satellites at 23,222 km.

Next are 450 satellites in GSO at an altitude of 35, 786 km and 23 satellites in High Earth Orbit (HEO) at 37,500 – 50,000 km. The GSO band includes all television and radio broadcasting satellites, some weather satellites, and civilian and military communication satellites. Many HEO satellites monitor solar activity (space weather).

Finally, there are several satellites in Highly Eccentric Earth Orbits (HEEO), which range from 1000 km to 35,786 km in altitude. Such extremely elongated orbits have the advantage of long dwell times at a point in the sky during the approach to, and descent from, apogee -- thus giving them more time over target areas of the Earth's surface and less time over non-target areas. Sirius Satellite Radio, for example, uses HEEO orbits to keep two satellites positioned above North America while another satellite quickly sweeps through the southern part of its 24-hour orbit.

The apogee of HEEOs could potentially reach much further than 35,786 km in altitude, and indeed, authors such as T. A. Heppenheimer, John S. Lewis, and Buzz Aldrin have described potential HEEOs reaching to the vicinity of the Moon's orbit, which could be used for cycling habitats, transporters, staging sites, fuel depots, and tourist cruise ships.<sup>7</sup> One important advantage of such HEEOs is that it takes less propellant to get to them from LEO than to get to GSO. In terms of propellant, they are also easier to return from back to LEO. Because the apogee of such future space debris can reach even closer than 1000 km, even they are threatened by orbital debris.

It is plain to see from the above that thousands of companies and billions of people worldwide depend on satellites for news, entertainment, communications, travel, and protection from extreme weather. Governments worldwide also rely on satellites for intelligence, logistics, and communications. Finally, there are the insurance companies, which already have an estimated \$20 billion at stake. The amount of space junk in orbit has reached a crisis level, and unless something is done quickly, government-owned satellites and the \$200 billion commercial satellite industry will begin to suffer heavy financial losses. So what can be done to alleviate this crisis, which threatens not just space development, but our whole way of life?

### **The Low Latency Telerobotics/Telepresence Revolution**

Recent advances in low latency communications have taken place, which have enormous bearing on any potential orbital debris remediation or satellite rehabilitation.<sup>8</sup> The first involves the evolution of high bandwidth communication, i.e. bandwidth with a data transfer rate above 300 kilobits per second (kbps). The second involves the increasing sophistication of telerobotic (human-guided) operations, which often include robotic (autonomous) features bringing human cognition and dexterity (i.e. "telepresence") to remote sites. On Earth these advances can be seen with real-time or near real-time telepresence operating remotely in mines, surgical rooms, underwater areas, and military arenas. Many of the orbital debris interventions described below, while described in the popular literature simply as "robotic," are actually telerobotic operations, sometimes complemented by robotic sub-operations.

### **Remove, Reuse,<sup>9</sup> Rehabilitate**

Future space debris can be greatly reduced by requiring launch and satellite companies to construct 1) upper rocket stages that when spent automatically release residual propellants to prevent on-orbit explosions, 2) stages or satellites that will power themselves into decaying orbits after use or 3) stages and satellites that will wind out sails, balloons, or electrodynamic tethers in order to de-orbit. Insurance companies could also conceivably offer lower rates to companies putting space structures in bands populated by satellites with de-orbit or parking-orbit features. Although there is no international treaty mandating these steps, the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) did publish voluntary guidelines in 2007.

Beyond future reduction through technology fixes, however, key actors in the space community should be able to remove extant debris to safeguard the destruction of expensive satellites; reuse satellite parts such as antennas and solar arrays, after scavenging them from dead satellites; or rehabilitate dead satellites by refueling and/or repairing them, then putting them back in operation. Who, however, would pay for such removal, repurposing, and rehabilitation, and how could it be accomplished? Also, could some of the technologies used for these three interventions be used for other space-development purposes?

### **Space Junk for Profit and Infrastructure Creation**

There are at least two good reasons for starting orbital debris remediation at LEO. To begin with, it is the area most crowded with debris and therefore most likely altitude band to host the next catastrophic collision. Second, dealing effectively with LEO and higher-altitude debris will generate new space industries, while laying down cis-lunar infrastructure for future space development. In this latter regard, it bodes well to keep in mind Robert A. Heinlein's famous quotation, "Reach low orbit and you're halfway to anywhere in the Solar System." The point of Heinlein's statement is that the amount of energy it takes to



go from Earth's surface to LEO (9.3 to 10 km/sec) is roughly equivalent to the energy required to travel from LEO to the planets.

Below 600 km in altitude orbital debris will self-remove within a few years due to atmospheric drag.<sup>10</sup> Intervention to remove debris above that altitude should therefore be a primary focus. But how can the removal of such orbital debris be carried out, and who will do it? And how does the recent telerobotics revolution fit into this picture? As it turns out, the Swiss Space Center at Ecole Polytechnique Federale de Lausanne (EPFL) in partnership with private company Swiss Space Systems (S3) is planning to build a family of "CleanSpace" satellites specifically designed to clean up LEO space debris.<sup>11</sup> EPFL, with other industrial partners, will build the de-orbiting satellites, and S3 is building a Suborbital Reusable Shuttle (SOAR), which will ride atop an A300 jetliner airbus to cruising altitude at which time the SOAR takes off and when it reaches 80 km altitude, ejects a spacecraft, which releases the de-orbiting satellite at 700 km altitude. Since the airbus and shuttle are reusable and utilize standard fuels, the system is deemed to be cost-effective.

The first CleanSpace satellites are being designed to reach a velocity of 28,000 km/hr (17,388 mph) as they approach their target dead satellites or debris pieces orbiting at an altitude of 630–750 km, at which point they will extend a strong gripper to grab the target and power it down to burn up in the atmosphere. EPFL is planning to have S3 launch CleanSpace One, a prototype de-orbiter outfitted with a gripping device, in 2018. To carry all this out, EPFL is designing a new type of ultra-compact motor and an elaborate gripper mechanism, which will also have to deal with the rotation of the target. The development of these new technologies will not be easy, but, if successful, the potential applications are far-reaching. Such technologies, for example could be modified to deal with various types of targets at various altitudes and orbits, such as near Earth asteroids (NEAs).

The "laser broom" and other concepts simply to remove debris also deserve mention. Laser broom would be a ground-based laser powerful enough to ablate the front surface off a debris target to slow and thereby de-orbit it. Although the U.S. Air Force in the late 1990s worked on a ground-based laser broom design named "Project Orion"<sup>12</sup> and a test-bed device was scheduled to launch on a 2003 Space Shuttle, numerous international agreements forbidding the testing of powerful lasers in orbit have impeded the program. Other proposed solutions include using giant balls of aerogel or styrofoam, nets, balloons, and electrodynamic tethers to slow or capture space debris.<sup>13</sup>

Rather than simply de-orbiting debris or dead satellites, another public-private project is aiming at reuse parts of dead satellites in GSO. The DoD's Defense Advanced Research Projects Agency (DARPA), under a demonstration project called Phoenix, is teaming up with the private sector to harvest and "repurpose" (i.e. reuse on a different structure) still functional components from nonworking satellites in GSO to create new space systems at greatly reduced cost.<sup>14</sup> Beginning in 2016, the project proposes to remove used parts from retired U.S. government and commercial satellites and re-attach them to nano-satellites launched as secondary payloads, making space debris a resource.

Antennas are likely to be among the first targets, because one of the primary drivers of launch costs is their high weight and volume. To deal with antennas and other satellite parts, DARPA and its private sector partners are developing telerobotically enabled Servicer/Tender (ST) spacecraft to be connected wirelessly to ground and space-based human operators. Because all operators will be within the 75,000 km telepresence window, they will be able to carry out their operations in real time or near real time, a huge advantage.<sup>15</sup>

Also foreseen is a new technique called, "cellularization," wherein nanospacecraft able to carry out functions such as power, communications, attitude control would be launched into orbit as "ride along" payloads on commercial launchers. The ST spacecraft would be telerobotically directed to attach such miniature structures to large antennas or other large parts scavenged from dead satellites to in turn produce working satellites at a fraction of the cost of new ones launched from Earth. Also envisioned is the possibility that STs can deposit rehabilitated antennas and solar panels in orbiting "antenna farms," i.e. salvage yards where they can await use on various defunct satellites. The U.S. Air Force also has a project likely involving advanced telerobotics. Its S-37B unmanned space plane last December passed one year in orbit and is carrying out secret operations controlled off-site.

Bigelow Aerospace has plans for manufacturing four types of space tugs at least two of which could have a significant impact on our ability to deal with salvaged antennas and other orbital debris.<sup>16</sup> For example, Bigelow's planned Solar Generator Tug is designed to transport "large solar panels" to Bigelow habitats or other structures.

Another Bigelow vehicle, the Spacecraft Capture Tug, is equipped with two multiple-joint grapple arms for capturing various objects in space, including disabled spacecraft and small asteroids. The vehicle will be able to “return the captured object to a designated location for further actions, such as extravehicular servicing of a satellite at a space station.”

Beyond grab-and-plunge removal and grab-and-reuse systems, possibly using “boom electroadhesion”<sup>17</sup> for more efficacy in the grabbing, properly designed service/tender spacecraft could theoretically refuel, repair, or upgrade satellites as needed, thus rehabilitating them at a fraction of the cost of constructing a new satellite and putting it into orbit.

Recall that NASA shuttle astronauts have carried out five missions to repair and upgrade the Hubble telescope orbiting the Earth at 600 km. However, the recent advances in telerobotics described above are drastically changing how we might approach the rehabilitation or enhancement of such spacecraft. For this reason, perhaps, the Canadian company MacDonald, Detwiler, and Associates (MDA) 2010 Space Infrastructure Services (SIS) project envisioned both refueling and otherwise servicing satellites in orbit telerobotically.<sup>18</sup> Although MDA and Intelsat in 2012 cancelled their collaborative agreement in which MDA would develop a satellite capable of refueling and servicing Intelsat’s 50 currently operation satellites with an initial 280 million USD investment by Intelsat, MDA remains interested in the concept. In this connection it is important to note that in May 2013, NASA carried out a series of telerobotically operated “propellant transfer experiments” on an exposed platform of the International Space Station.<sup>19</sup>

### **Solar Electric Propulsion**

About 200 orbiting satellites use solar-electric ion or plasma propulsion (SEP), and the rest use chemical propulsion to be placed or stay in place. Because electric engines offer very high specific impulse and leave much less propellant residue at the end of a satellite’s lifetime, there is increasing enthusiasm for such engines in satellites and rockets destined for LEO or higher. NASA’s Jet Propulsion Laboratory working with space development companies has already produced SEP spacecraft, and a public-private Australian group is also developing SEP engines that will not have to use expensive noble gases for propellant.<sup>20</sup> SEP offers the potential for significant cost savings for emplacing or maintaining spacecraft in Earth orbits and cis-lunar spaces.

### **Legal Issues**

Without an adequate international treaty in place, a tangle of legal issues is likely eventually to arise from attempts to remediate orbital debris. Foremost among such issues is the ownership of debris fragments that any mission would gather or otherwise deal with. According to Michael Listner commenting in *The Space Review*,<sup>21</sup> Article VIII of the Outer Space Treaty vests ownership of any object or components of an object in the “State Party to the Treaty” that launched it into outer space, and therefore gathering such assets raises a legal obligation to either return them or get permission from the state ahead of time. Identifying the debris could theoretically be done with specific intact but defunct satellites. With 500,000 objects between 1 and 10 cm and smaller objects exceeding 100 million, the identification of the most dangerous debris is not feasible.

A related legal issue concerns the possibility that a given remediation attempt will misfire and create even more debris or the outright destruction of a working satellite. Insurance companies could play a role in defraying the economic costs of the latter eventuality, but the cost of such insurance for new debris-remediation technologies is likely to be high, unless careful stepwise testing is done first.

It would seem helpful that to deal with the above-mentioned and other legal issues, international stakeholders, both governmental and private, should work within UN COPUOS to expand and evolve the 2007 voluntary guidelines for orbital debris remediation into an international treaty. Such a treaty could also conceivably generate flexible orbital debris mandates for states and private companies to follow. Whether the treaty would also need to establish an authoritative body to monitor or enforce such mandates is a question that could be addressed as well.

### **Expanding the Cis-Lunar Economy and Infrastructure with Orbital Debris**

Telerobotic technologies for the removal, repurposing, and rehabilitation of orbital debris are obviously in their infancy and will grow in sophistication as time passes -- if public and private stakeholders collaborate in a timely fashion to ensure profits and sustainable businesses. Moreover, space debris remediation businesses could be given great impetus by purposely designing satellites to facilitate their future removal, repurposing, and rehabilitation as needed.

Sooner or later in this process, antenna and solar array salvage yards and other orbiting depots will evolve into space complexes holding propellant tanks, satellite and spacecraft parts, and idle ST spacecraft. Large platforms in GSO could theoretically host multiple satellites and thus possibly get around the 180 slot limit in GSO. It is easy to imagine depot complexes and other structures further evolving into staging areas for in-space tugs, tankers, freighters, and taxis. Orbiting manufacturing and processing sites for lunar and asteroidal materials could follow, as well as hotels and tourist cruise ships in HEEOs. Orbital debris remediation could be the first step in further expanding a cis-lunar economy and infrastructure, and this step could be taken in a rational incremental fashion -- or we can wait until space debris collisions force us to take desperate and costly measures to save our modern way of life.

We therefore have the plainest of choices: We can wait until our way of life is threatened with destruction and then pay dearly to rectify the situation, or we can deal with it now and use orbital debris remediation to expand Earth's economy, build solar system infrastructure, and begin our climb to the stars.

#### FOOTNOTES:

- <sup>1</sup> NASA Orbital Debris Program Office, "Orbital Debris Frequently Asked Questions." (<http://orbitaldebris.jsc.nasa.gov/faqs.html#7>), 12 November 2013.
- <sup>2</sup> Geosynchronous Orbit is often abbreviated as GEO, but GEO technically refers to a subclass of geosynchronous orbit called a Geostationary Orbit, a circular geosynchronous orbit for a spacecraft at zero inclination (i.e, directly above the equator), instead of tracing out a path typically in the form of an analemma over the course of a day.
- <sup>3</sup> Kessler, D. J., and B. G. Cour-Palais (1978), Collision frequency of artificial satellites: The creation of a debris belt, *J. Geophys. Res.*, 83(A6), 2637-2646, doi:[10.1029/JA083iA06p02637](https://doi.org/10.1029/JA083iA06p02637).
- <sup>4</sup> Lisa Grossman, "NASA considers Shooting Space Junk with Laser," *Wired*, 15 March 2011; National Research Council, "Orbital Debris: A Technical Assessment," The National Academies Press, 1995.
- <sup>5</sup> Donald Kessler, "The Kessler Syndrome" (<http://webpages.charter.net/dkessler/files/KesSym.html>) webpages.charter.net, 8 March 2009
- <sup>6</sup> Mainly from the Union of Concerned Scientists Satellite Database.
- <sup>7</sup> T.A. Heppenheimer, "The Highest Home," *Colonies in Space*, pp. 110-111, 1977; John S. Lewis, *Mining the Sky, "Power from the Sun, the Moon, and Asteroids,"* pp. 132-134, 1996; Buzz Aldrin, "Your Space: Building the Business Case," *Mission to Mars*, p. 52. HEEOs are sometimes called Highly Elliptical Orbits (HEOs).
- <sup>8</sup> Leonard David, "Remote Telepresence: A New Tool for Space Exploration?" *Aerospace America*, February 2013.
- <sup>9</sup> Reuse is sometimes termed "repurpose." "Recycle," on the other hand, refers to reprocessing defunct or waste spacecraft.
- <sup>10</sup> Dangerous debris exists at lower levels, however. For example, on two occasions, in 2009 and again in 2011, the crew of the ISS have been forced to abandon work and take refuge in the Soyuz capsule while a debris threat passed. (The International Space Station orbits at an altitude of around 400 km.)
- <sup>11</sup> Lionel Pousaz, "The Time Has Come to Destroy Debris," <http://www.s-3.ch/en/mission-goals>; Emmanuel Barraud, "Cleaning up Earth's Orbit: A Swiss Satellite to Tackle Space Debris," *Mediacom*, [www.s-3.ch/en/mission-goals-and-actu.epfl.ch/news/cleaning-up-earth-s-orbit-a-swiss-satellite-to-tac/](http://www.s-3.ch/en/mission-goals-and-actu.epfl.ch/news/cleaning-up-earth-s-orbit-a-swiss-satellite-to-tac/). S3 is itself partnering with 12 other companies and one major investor/sponsor (Breitling).
- <sup>12</sup> Ivan Bekey, "Project Orion: Orbital Debris Removal Using Ground-based Sensors and Lasers (<http://adsabs.harvard.edu/abs/1997ESASP393/699B>).
- <sup>13</sup> J.T. Quigley, "Japan will Cast a 'Magnetic Net' for Space Junk, 16 January 2014; Aviva Hope Rutkin, "Japan's Huge Magnetic Net Will Trawl for Space Junk," *New Scientist*, 22 January 2014.
- <sup>14</sup> Paul Dykewicz, "DARPA Advances Plans to Salvage Antennas of Retired, In-Orbit Satellites," [www.onorbitwatch.com/program/darpa-advances-plans-salvage-antennas-retired-orbitsatellites](http://www.onorbitwatch.com/program/darpa-advances-plans-salvage-antennas-retired-orbitsatellites), 24 November 2013.
- <sup>15</sup> For the telerobotics operator to experience real time or near real time, the relevant telerobot (often simply called a "robot") must be at within 75,000 km. This literally brings human cognition (telepresence) to the operating area. Over 75,000 km in distance, however, teleoperations suddenly become extremely slow and inefficient.
- <sup>16</sup> Yves-A. Grondin, "Affordable Habitats Mean More Buck Rogers for Less Money Says Bigelow," *NASA Spaceflight.com*, 7 February 2014.

- <sup>17</sup> Colorado-based Altius Space Machines is developing a robotic arm system called the “sticky boom,” which can extend to 100 meters. At the end of the boom is a pad induces electrostatic charges onto any material it comes in contact with, facilitating the grip on such an object. See Jeff Foust, “A Sticky Solution for Grabbing Objects in Space, MIT Technology Review, 5 October 2011.
- <sup>18</sup> “Intelsat Picks MacDonald, Dettwiler, and Associates Ltd. For Satellite Servicing,” [www.mdacorporation.com/corporate/news/pr/pr2011031501.cfm](http://www.mdacorporation.com/corporate/news/pr/pr2011031501.cfm), 15 March 2011; Joel Spark, “MDA, Intelsat Cancel On-Orbit Servicing Deal,” Space Safety Magazine, 20 January 2012; Jeff Foust, “The Space Industry Grapples with Satellite Servicing,” The Space Review, 25 June 2012.
- <sup>19</sup> Adrienne Alessandro for Goddard Space Flight Center, “NASA’s Robotic Refueling Mission Practices New Satellite-Servicing Tasks,” Space Daily, 13 May 2013.
- <sup>20</sup> <http://sec353ext.jpl.nasa.gov/ep/index.html>; Marc Ficshou, “New Space Technology – Electric Propulsion for Satellites,” [www.satmagazine.com/story.php?number=235801980](http://www.satmagazine.com/story.php?number=235801980).
- <sup>21</sup> Michael Listner, “A Brief Look at the Legal and Political Implications of Japan’s Space Debris Removal Plans,” The Space Review, 27 January 2014.

## NASA readies Orion Capsule for first test flight

<http://spectrum.ieee.org/aerospace/space-flight/nasa-readies-orion-for-first-test-flight>

By Dave Dunlop

### NASA's bid for an exploration vehicle beyond LEO

It is part of the too expensive to fail Space Launch System which includes the \$2B SLS vehicle plus and European support module for the Orion capsule. The Orion design to be launched on this year on an EELV for an unmanned test. In 2017 it is supposed to be tested on an unmanned "loop the Moon Mission," In 2021 it is supposed to undertake its first manned mission to investigate a small asteroid in cislunar space.

If the SLS system is undone by the Falcon 9 Heavy system could the Orion capsule survive this loss of its primary launch vehicle and be launched instead on a Falcon 9 Heavy?

#### We hope the answer is yes.

The Orion and its European support system might then survive to provide a less expensive manned system beyond LEO. That would keep the NASA jobs alive that support the Orion system. But by then what might the commercial sector have produced?

A **Bigelow capsule** by intent and design is for longer term use on a space station or even on the lunar surface. Do we really need something as expensive as Orion to conduct long term missions beyond LEO?

Would it not make more sense to have a larger more permanent vehicle like a Bigelow module but alternatively use a small crew return capsule that could either aerobrake in the upper atmosphere to return to a circularized LEO orbit and return to the ISS if needed?

The commercial crew program would appear to be providing vehicles that could do this except that the heat shield requirements have not been designed for lunar return speeds from lunar orbits. The commercial crew vehicles also have limited duration life support systems.

What if the Boeing CST-100 vehicles, Dragons, or Dream Chasers were boosted to a E-M Lagrange station with a vehicle that could also provide the needed life support services? Could these vehicles provide part of an architecture can provide a reasonable cost supply chain for E-M Lagrange as well carrying both crew and cargo up and back to LEO?

In that case the commercial crew program for the ISS could also be part of the building blocks to push manned presence out to an Earth Moon Gateway station.

If the NASA Human Exploration Program for cislunar space beyond LEO were to be competed program I suspect the Orion program would be an affordable component. In its protected and uncompleted status as a NASA jobs program there are no competitive pressures. Orion might have a unique use as a lifeboat that could return directly to Earth if needed from lunar distances.

The European support component for Orion could and should be designed to boost a variety of different capsule out to the Moon. If it would have a standard adaptor ring then potentially Boeing CST-100, Dream Chaser, Soyuz, and Space-X could be used to get "out there". At some point it seem likely that Chinese capsules or an ISRO manned capsule could be part of this architecture as well.



It could be also used in the creation of an E-M Lagrange if nothing else as shielding mass. If designed to be serviced itself it might provide many functional uses for life support, power supply, storage of consumables and shielding mass.

We can hope that the Global Exploration Roadmap can be upgraded and revised to include a more collaborative architecture. If an Internationally financed corporation were to specify its requirements some of the things suggested above would make sense. The recently completed International Space Exploration forum was witness to US statement about increasing the international use of the ISS and also of increasing the commercial use of the ISS. It would be nice if we saw the same spirit of collaboration and commercial flexibility being used with regard to the future architecture beyond LEO.

The big threat to the SLS system is the success of the Falcon 9 Heavy and the demonstration of a much reduced cost high flight rate reusable Falcon 9 rocket with a manned rates Dragon capsule. The DragonLab is yet another demonstration of the remarkable ability of Elon Musk to play the chess games many jumps ahead of his competitors. ##

## Building a Bridge To Terrestrial use of Space Solar Power

By David Dunlop and Al Anzaldua – April 1, 2014

### **The Enormous Gulf between Space-Based Solar Power (SBSP) and Ground-Based Power (GBP)**

Jeff Landis is quoted as saying that “electrical power in space has an effective price tag that is 10,000 time the price of power on the ground.”<sup>1</sup> Arthur Smith in a 2004 paper cites NASA contract figures as the basis of a \$20,000,000 per kW capital cost on the International Space Station. The \$600 kWh electrical consumption cost on the ISS is compared with the \$ 0.036 per kWh for coal fired plants and . \$0.05 kWh for natural gas.<sup>2</sup> He also lays out comparative cost data for a range of power production technologies and factors which must be addressed in reducing the great disparity between space solar power today and other terrestrial supply options. Commercial baseload price around the world may vary from single digit cents per kWh to several tens of cents per hour on spot markets during times of peak demand. Paul Werbos, in a 2013 IEEE Space Solar Power Workshop presentation has projected that a cost of \$.09kWh would be needed for space solar power to supplant other technologies for commercial baseload electrical supplies.<sup>3</sup>

Bridging the enormous gap between the current and projected cost of electric power in space and that on Earth is therefore a big challenge for advocates of space solar power. On the one hand harnessing the power of the Sun to provide a virtually limitless source of usable energy for civilization is the “Pot-o-Gold at the End of the Rainbow” for this community. On the other hand, one can hardly blame skeptics for questioning the potential of trying to sell something presently ten thousand times more expensive in space than on Earth. One can see why advocating for space solar power has been right up there with catching Leprechauns, and why it has been difficult to convince Congress to support research and development for SBSP.

### **Competitive Technology**

Another visionary potential source for clean power is from commercial fusion, and Arthur Smith describes the International Thermonuclear Experimental Reactor (ITER) research program at a projected capital cost of \$40,000 per kW and a consumption cost of \$4.70 kWh. The ITER program capital cost is some 26 times the cost per kW of a coal powered plant, while the cost per kWh is over 130 times that for coal. But even with this comparative disparity between the commercial market’s and the projected ITER plant’s consumption cost, there has been long-term international support for nuclear fusion power research. Can we make a convincing case for research on space solar power satellites? Smith says, “But three to four orders of magnitude [improvement in cost efficiency] is a very large extrapolation, and it will only be believable if we can build a number of intermediate demonstrations to prove these reductions are achievable.”<sup>2</sup>

### **Solving a Daunting Problem**

Human civilization’s continuing existence is not sustainable on a small crowded planet whose environment is being degraded by fossil fuel power generation and by the demands of a growing population with rising expectations and limited resources. The mid to long-term perspective for sustaining civilization calls for what many would see as “miracles” of technology. There are also many prophets of doom. Yet abundant power for all is the practical goal for space solar power advocates. So against this immense gulf between SBSP and GBP, the prospects are grim if we don’t solve this problem of relative costs between the two types of power systems. On the other hand, the rewards are huge if we do.

Getting the costs of power in space down by several orders of magnitude is a tall order. Indeed, studies of the feasibility of space solar power since this was first suggested by Dr. Peter Glaser have shown SBSP to be economically unfeasible.<sup>4, 5</sup> More recently, some hope has been provided by the First International Assessment of Space Solar Power, which suggested that the development of this power technology to supply baseload electrical power might be done within the span of two to three decades.<sup>6</sup>

A bridge of affordable development options is needed to get from what it would cost to produce power in space today to producing power at commercial baseload prices on Earth. To begin we can do some things that are modest and affordable on the ground. We can also do some things that are less modest but still affordable in space and also provide further development incentives.

### **Building the On-Ramp to SBSP from the Ground Up**

The promise of “clean” power from solar power satellites makes this a “green solution” to the energy supply problems. But is it? Environmental skeptics of large technological projects have often acted to obstruct such efforts and to demand evidence that the purported solution to energy production are in fact benign to the environment. More specifically, wireless power beaming skeptics might advocate for environmental demonstrations based on long-term studies of the impact of power rectennas over agricultural and natural environment test areas.

Long duration microwave trials should address environmental questions about the environmental impact of rectenna systems in a variety of environmental settings. Diverse locations come to mind: the Mt. Erebus overlook of the McMurdo base in Antarctica, the China Lake Naval Research Station in the Mohave Desert in California, or even the Thule Air Force Base in Greenland, where a Mountain radar installation overlooks the base. These suggested settings are remote and therefore not susceptible to the not-in-my-back-yard (NIMBY) reactions in more populated areas, and they are on restricted federally operated facilities. These demonstrations need, however, to be open, transparent, and peer reviewed environmental studies so that results are credible and well publicized.

The cost of power connected to disaster-relief supply chains for refugees in remote areas may range from \$2.00 per kWh to \$3.00 per kWh, some 40 to 60 times commercial baseload power prices.<sup>8</sup> Nature and war provide a “conveyor belt” of natural disasters affecting tens of millions of people each year with transitional power needs lasting several months to years. Associated disaster-relief supply chains may eventually provide early demonstration targets for SBSP microwave beaming, widely supported by the International Community.

Another opportunity connected to disaster relief might involve using beamed power transmitted from an offshore ship (as one example) to an aerostat with retransmission far inland where no power is available. This Over-the-Horizon-Wireless-Power-Beaming (OTHWPB) could be a way to utilize and mature power beaming technology that by-passes insecure and expensive ground-based supply chains.<sup>7</sup> The devastating hurricane in the Philippines in December of 2013 was an example of where this type of beamed power generation could have served humanitarian needs. OTHWPB would not only demonstrate technology for delivering electrical power at a high cost per kWh in time critical situations for disaster and refugee relief, it would also address safe-use concerns and build on the international support that the UN Platform for Space-based Information for Disaster Management and Emergency Response (SPIDER) program has garnered by obtaining space-based imagery of post disaster conditions from Earth observations satellites.<sup>8</sup> As such, the UN SPIDER program provides an early demonstration of how space applications can improve the lives of citizens on Earth.

OTHWPB technology might later apply to point-to-point microwave or laser power supply on the Moon,<sup>9</sup> where high altitude “peaks of eternal light might provide transmission points to lower elevations in permanently shadowed regions where frozen volatiles could be mined and recovered.” Earth-based line of sight studies using lasers are a model for lunar-based point-to-point laser power supply.

Even a small space solar power demonstrator satellite would be an expensive proposition. However, one evolutionary step could be to build a multipurpose geostationary (GEO) demonstrator platform that could function as a 1) large transponder farm for radio and TV broadcasts; 2) site for large reception dishes to receive and relay cell phone signals for millions of paying users; 3) site for refurbishing dead satellites and utilizing space debris as on-orbit construction material for the site itself; and 4) site to provide an array of standardized energy collection and transmission modules as suggested in the NASA Institute for Advanced Concepts (NIAC) 2012 study.

This last function would involve setting up the manufacturing and supply chain for SBSP modules. It would also provide a test bed to optimize efficiencies and reduce costs to levels more in keeping with GBP. Even so, the economic rationale for an early energy collection and transmission platform would be more acceptable if it targeted its power-beaming demonstrations at the very high cost ground niche market for disaster relief and refugee support, rather than at baseload ground market.

## Stepping Stones toward SBSP

Al Globus has stated that “space solar power’s greatest weakness is that its profitability depends on supplying very large quantities of power, unless a small niche market willing to pay high prices can be found. Beyond disaster and humanitarian aid, another such market might be space-to-space power, i.e., powersats supplying power not to the ground, but to other spacecraft and perhaps to lunar sites.”<sup>10</sup> In other words, the path to SBSP for the Earth’s surface could begin with existing spacecraft in orbit, such as the International Space Station (ISS). In fact, the ISS could provide the main pathway to expanding and reducing the cost of SBSP.

### Building the On-Ramp for SBSP via the ISS

With wise utilization of the ISS, we could test and develop new materials, such as higher-efficiency radiation-hardened photovoltaics with a useful life much longer than current spacecraft materials. Consistent with the existing technology interests and funding programs of the Space Technology Mission Directorate, we could demonstrate the potential for cost reduction through scalability.<sup>11</sup> ISS-based development would provide multiple opportunities to test and refine new space power technologies. Finally, the ISS could provide a test bed for an early demonstration of a robotically coordinated constellation of space power collection and beaming modules, sharing a common guide beam for focus on a collecting rectenna, as proposed by Gary Barnhard of Xtraordinary Innovative Space Partnerships, Inc. (XISP).<sup>12</sup>

**Step One.** A beginning step could be utilizing Dr. Mankins’ proposed architecture<sup>13</sup> of hexbot propulsion/control assemblies in a ring of 6 solar modules with an aperture of 5m<sup>2</sup> and a mass of 2,000 kg providing 1 kW. This architecture could provide a small scale demonstration in an orbit proximate to the ISS.

**Step Two** would expand this initial ring to 18 hexbot assembly modules with an aperture of 180 m<sup>2</sup> and a mass of 3000 kg providing 8 kW.

**Step Three** would expand to 60 hexbots with an aperture of 600 m<sup>2</sup> and a mass of 6,000 kg providing 16 kW.

**Step Four** would expand to 120 hexbot modules with 1200 m<sup>2</sup> aperture & 12,000 kg providing 32 kW.

### Technology Advancements.

NASA’s Space Technology Mission Directorate (STMD) and Human Exploration and Operations Mission Directorate (HEOMD) are well aligned with elements of John Mankins’ space solar power development strategy. Mankins’ proposed SBSP architecture, which builds on the existing programmatic and budgetary foundations would:

- 1) Test and develop high performance photovoltaic cells in solar power modules with the long-term ability to maintain their position and orientation using solar electric propulsion (SEP) in an array for optimal solar energy reception and beam transmission;
- 2) Demonstrate that its modules can be refueled and otherwise serviced as needed;
- 3) Demonstrate solar power modules that can be oriented or even moved with SEP to provide power to materials-processing facilities sharing similar or different but accessible orbits, such as those in GEO or in Earth-Moon Lagrange orbits.

In general, the above proposed demonstrations at or near the ISS provide an affordable near-term opportunity to test architectures for much larger solar power satellites in a way that builds from the smallest practical array and then scales up the number of modules for other energy applications in a variety of cislunar locations. A delivery system that is a regular feature of ISS supply-chain flights could help demonstrate the scalability of modular SBSP assemblies.

If solar power satellites are to overcome the enormous cost gap between fossil fuels and today’s space solar power the cost estimation relationships (CER) for the manufacture of power modules must drop radically. Mankins has shown that early high cost elements of the SBSP CER can be retired with a preliminary demonstration program.<sup>14</sup> In other words, subsequent demonstrations could provide much lower manufacturing and deployment cost estimates, and over a several year period of deployment a significant reduction in the costs could be realized.

The role of the ISS in space solar power evolution are exciting because its extravagant costs for deployment are “already sunk,” and its extended operational commitment to 2024 creates a time frame adequate for these proposed early demonstrations. The ISS contains many features which provide the conditions for an early demonstration of many of the elements of the ALPHA concepts: its own supply redundant international supply chain, manned EVA capabilities, robotic grappling and docking, power, an antenna that can be used as a guide beam, and a potential for servicing and refueling. A demonstration

power array also provides a growth path for new ISS capacities and an alternate power supply system if its current system should suffer a major malfunction.

Many of the other early research and development objectives in refueling, solar electric propulsion, robotic systems, materials, and operations can also work synergistically in an early program. Practical experience can feed back into improved iterations of design, manufacturing, deployment, operations, and redeployment. Reusable rockets and in-space vehicles can also accelerate cost reductions so that the cost trend line for space solar power is steeply downward. Cost efficient strategies might include launching space power modules as secondary payloads, thus making profitable use of unused lift capacity.

The proposed ISS-connected demonstrations also build on the foundation of international cooperation and partnership, which permit shared participation in the investment, development, and utilization of ISS-connected new technologies. Production facilities can be prototyped and evolved among a variety of international supplier partners. The proposed SBSP technology investments and demonstrations would also buy down the risk of commercial investment for large GEO communications platforms interested in using telerobotic servicing, AI-coordinated modular power arrays, or fueling depots needing power to maintain cryogenic storage and transfer fuels.

The proposed ISS-connected architecture could lay the foundation for further evolutionary steps toward large-scale SBSP for use on Earth, in Earth orbits, and even in deep space, where the potential utilization of asteroidal and lunar resources reaches well beyond the ten year time frame of this discussion.

### Summary

The ISS-connected steps proposed above will advance the level of knowledge for ground infrastructure and systems, in-space applications, and infrastructure requirements for space solar power. There is now at least a ten year operations window for the ISS so the steps suggested above have strong likelihood of accomplishment within that planning timeframe if an ISS SPS demonstration program can be quickly initiated. Implementing the suggested steps will also advance the infrastructure needed for further research and development and innovation. What has been suggested will also broaden international participation so that those sharing the risks, costs, and benefits will benefit from additional partnerships. If these steps suggested are taken by 2024, technological advances to address the challenge of using in-situ resources on the Moon or from near-Earth asteroids may further narrow the gulf in prices between space produced power today and the promise of space solar power for both spacecraft and for baseload requirements on the Earth. The ISS bridge strategy proposed by Mr. Barnhard begins to address the requirements mentioned by Arthur Smith in 2004 and laid out by John Mankins' 2012 NIAC study.

### Notes:

- <sup>1</sup> NASA Glenn research reported by Jeff Landis on inverted metamorphic solar cells (IMM) <http://www.boeing.com/assets/pdf/defensespace/space/spacestation/systems/docs/ISSElectricPowerSystem.pdf> Space Quarterly, 11 June 2012.
- <sup>2</sup> Arthur Smith, "Economic Prerequisites for Space Solar Power," Proceedings of the 4<sup>th</sup> International Conference on Solar Power from Space – SPS '04, together with the 5<sup>th</sup> International Conference on Wireless Power Transmission – WPT (ESA SP-567) 30 June–2 July 2004, Granada Spain. Organized by ESA, CO-sponsored by Ministerio de Ciencia y Tecnologia, Ciemat, USEF, CDTI, EADS SpaceTransportation.
- <sup>3</sup> Paul Werbos, "Energy From Space: Challenges ahead from Technical to Political, Space Solar Power Workshop," 2013, IEEE WiSEE/Meeting, Baltimore, November 8,9 2013, (<http://sites.ieee.org/wisee/>)
- <sup>4</sup> Solar Power Satellites: an AIAA Position Paper. American Institute of Aeronautics and Astronautics, November 29, 1978.
- <sup>5</sup> John C. Mankins, "A Fresh Look at Space Solar Power: New Architectures, Concepts, and Technologies," International Astronautical Federation, IAF -97-R.2.03, 12 pages, 1997.
- <sup>6</sup> First International Assessment of Space Solar Power, IAA, 2011.
- <sup>7</sup> Paul Jaffe and Steven Blank, IEEE WiSEE, Space Solar Power Workshop, Baltimore, November 8–9 2013.
- <sup>8</sup> United Nations Platform for Space-based Information for Disaster Management and Emergency Response– UN-SPIDER Knowledge Portal: [www.un-spider.org](http://www.un-spider.org)
- <sup>9</sup> P. Ashanti, M.S. Robinson, A. Boyd and S. Lawrence, Lunar Reconnaissance Orbiter, Science Operations Center, Arizona State University, Tempe, Arizona  
LPI Contribution No. 1748 Annual Meeting of the Lunar Exploration Analysis Group  
October 14–16, 2013 Laurel Maryland., Lunar and Planetary Institute.



- <sup>10</sup> Al Globus, <http://space.alglobus.net/papers/FetterResponse.html>
- <sup>11</sup> NASA RFI Support of Low Cost Solar Array Technologies in Support of High Power Solar Electric Propulsion, December 20, 2013, Solicitation Number NNC14ZCH012L, NIACS Code 541712. NASA Glenn Research Center
- <sup>12</sup> Gary Barnhard, [www.xisp-inc.com/index-6-projects.html](http://www.xisp-inc.com/index-6-projects.html), Annex 7 Space-to-space/SurfacePower Beaming.
- <sup>13</sup> John C. Mankins details this progression in growth in the SPS-ALPHA: The First Practical Solar Power Satellite via Arbitrarily Large Phased Array (a 2011-2012 NASA NIAC Phase One Project), Final Report to NASA, 15 September 2012, page 55 and 57. Similar propositions by Gary Barnhard (see above footnote) illustrate scalability.
- <sup>14</sup> Mankins, op. cit. 2012, pages 40-41. **8.** These proposed demonstrations at or near the ISS could provide an affordable near term opportunity to test an architecture for much large solar power satellites in a way that builds from the smallest practical array and then scales up the number of modules that are needed for other applications in a variety of cislunar locations: such as material processing facilities, and Earth-Moon Lagrange station, or a GEO communications platform. A delivery system that was a regular features of the ISS supply chain flights could provide a demonstration of the assembly systems and the scalability of this system.

If SSPS are to overcome the enormous cost gap between fossil fuels and today's space solar power the cost estimation relationships (CER) for the manufacture of power modules must drop radically. Mankins has shown the early high cost elements of the CER can be retired with a preliminary demonstration program. (9), 4.3 pages 40-41). Subsequent demonstrations can provide much lower manufacturing and deployment costs. Over a several year period of deployment a significant reduction in the costs could be realized.

The role of the ISS in space solar power evolution are exciting because its extravagant costs for deployment are "already sunk" and its extended operational commitment to 2024 creates a time frame adequate for these proposed early demonstrations. It contains many features which provide the conditions for an early demonstration of many of the elements of the ALPHA concepts: its own supply redundant international supply chain, manned EVA capabilities, robotic grappling and docking, power, an antenna that can be used as a guide beam, and a potential for servicing and refueling. A demonstration power array also provides a growth path for new ISS requirements and an alternate power supply system if its current system should suffer a major malfunction.

Many of the other early research and development objectives in refueling, solar electric propulsion, robotic systems, materials, and operations can also work synergistically in an early program. Practical experience can feedback in the iterations of design, manufacturing, deployment, operations, and redeployment. Reusable rockets can also accelerate these cost reductions so that the cost trend line for space solar power is steeply downward.

**9.** These demonstrations also build on the foundation of international cooperation that is the ISS partnership and permit shared participation in the investment, development, and utilization of these new technologies. Production facilities can be prototyped and evolved among a variety of potential international supplier partners.

**10.** These demonstrations also build the foundations for expanded commercial participation by buying down the risk of commercial investment:

- a For large GEO communications platforms by buying down the risk with early demonstration of critical capabilities in telerobotic serving and AI, coordinated modular power arrays.
- b For fueling depots that will need power to maintain cryogenic storage and transfer fuels.
- c For materials processing facilities that use old satellites and use retrieved "space debris" as the low hanging fruit of a nascent ISRU industry. There will be a need for truss assemblies in the proposed ALPHA design. (9) (Section 3.5.4 pg. 33) The use of materials from dead satellites that are retrieved could serve both the demands of space debris reduction. The utilization of existing stocks of highly refined metal from spent boosters and satellites, the demonstration of remanufacturing of spar components with technologies such as 3D printing, and beam builders.
- d Similarly a large GEO platform with adequate power resources might also include large aperture dishes for cell phone signal reception to support that mass communications market. These facilities could supplant existing cell tower requirements and provide of recovered satellites and rocket booster materials

e For demonstrating the ability to use solar electric propulsion systems to move mass more cost efficiently in cislunar space, than heritage chemical propulsion, and especially beginning with unmanned supply chain applications.

11. These demonstrations can also utilize cost efficient strategies to launch space power modules for these early demonstrations as secondary payloads on existing launch systems, such as the ISS supply launches. This can make profitable use of unused lift capacity of existing launches as well as pioneering use of new lower cost reusable launch systems.

12. The power production architecture developed in this early ISS demonstration also lays the foundations for further evolutionary steps toward large SPS and further reduction of costs from efforts to process raw materials from asteroids or on the lunar surface, or supplying power for a lunar mass driver or other lunar surface requirements beyond the ten year time frame of this discussion. ##

## The “Lunar Track” at ISDC 2014, Los Angeles, CA

By David Dunlop

The Lunar Track at the 2014 International Space Development Conference, Los Angeles, CA| The 2014 Lunar Track at ISDC will include a diversified set of presentations ranging from the space radiation environment for human crews from Dr. Dennis Wright of Stanford Linear Accelerator, and Dr. Doug Plata, a Family practice physician, to a special presentation by the Mercury Messenger Team in the morning session. In the afternoon we will be privileged to get on update on the Google Lunar X-Prize from its Chief Technical Officer Dr. Andrew Barton, and from several GXLP Teams including BoB Richards of Moon-X, Michael Paul of the Penn State Lunar Lions, and Maria Catalina from Synergy Moon. We will also hear presentation about cislunar cycling orbits from Al Anzaldua of NSS Tucson, and cislunar economics from Brad Blair of New Space Analytics. The proposed International Lunar Geophysical campaign will be an additional presentation.

**The schedule of the Lunar Track** is Friday, May 16<sup>th</sup> features the speakers shown as follows:

### Morning

10:00 AM – 10:25 AM	Dennis Wright Ph.D.	Stanford University Linear Accelerator
10:25 AM – 10:50 AM	Doug Plata, M.D., M.P.H,	Family Medicine Practitioner
11:00 AM – 11:40 AM	Messenger Team	(Speakers to be identified)
11:40 AM – 11:50 AM	Student Presentations	

### Afternoon

2:00 PM – 2:25 PM	Andrew Barton, Ph.D. CTO,	Google Lunar X-Prize
2:25 PM – 2:50PM	Michael Paul, Team Leader,	Penn State Lunar Lions
3:00 PM – 3:25 PM	Bob Richard Ph.D	CEO, Moon-Express
3:25 PM – 3:50 PM	Dave Dunlop	NSS International Committee, Chair
4:00 PM – 4:25 PM	Maria Catalina Team Leader	Team Synergy Moon
4:25 PM – 4:50 PM	Al Andulzua, President	NSS Tucson
5:00 PM – 5:25 PM	Tom Bauer, Chief Scientist,	Microcosm, Inc/Scorpius Space LaunchCo
5:25 PM – 5:50 PM	Brad Blair, President,	New Space Analytics LLC

## Supporting Space on the Space Coast

By David Dunlop

To further Lunar and space exploration, the 4<sup>th</sup> International Workshop on Lunar and Planetary Compact and Cryogenic Science and Technology Applications, or Lunar Science Applications for short, will be held April 8–11, 2014, at the Courtyard by Marriott in Cocoa Beach, Florida. Scientists, engineers, entrepreneurs and the interested public are invited to attend. ([www.lsaworkshops.com](http://www.lsaworkshops.com).)

### Three Days of Technical Presentations

Wednesday, April 8, the technical presentations will focus on Science and Science Concepts. The morning session is on Current Understanding of Volatile Distribution and Processes and the afternoon is on Proposed Volatile Investigations, Instruments, and Concepts.

Thursday, April 9, technical presentations will focus on Cryogenic and/or Compact Engineering Capabilities and Challenges. Morning presenters will talk about Cryogenic and/or Compact Subsystems and Components while afternoon presenters will talk about High Temperature Superconductor-based Cryogenic Systems.

There's a lot more to Kennedy Space Center these days than launches.

Friday, April 11 will put the event's participating sponsor, KSC is in the spotlight with presentations on "Finding Lunar Resources and Meeting Challenges of Resource-limited Exploration." The morning session will focus on "Concepts of Lunar Surface Exploration and Resource Utilization" while the afternoon session is about "Support for Exploration via Small Payloads."

All morning and afternoon technical presentations will be followed by interactive design challenges.

### **Keynote Presentations**

Wednesday's lunch keynote, John Thorton, CEO of Astrobotic Technology, Inc. and Thursday's dinner keynote, Bob Richards, CEO of Moon Express Inc., will provide updates on the progress of their Google Lunar X Prize missions. Friday lunch keynote will be a panel discussion with Deputy Director Janet Petro and other top management.

### **Meet and Greet Poster Session – Network with the Scientists**

On Wednesday evening 5:30–8:30 pm, prominent scientists and researchers in the field of space and Lunar exploration will do poster presentations about their research and will be available to answer questions about their projects in this evening "meet and greet" poster session.

A cash bar will be available and hors d'oeuvres will be served. No charge to the public.

### **Celebrating Yuri's Night**

Friday evening we'll kick off the weekend celebrations of Yuri's Night. April 12, 1961 was the day of cosmonaut Yuri Gagarin's first manned spaceflight. Exactly twenty years later to the day, NASA's Space Shuttle had its inaugural launch. Join us on Friday night at 5:30 pm, April 11, 2014 as Brevard County kicks off a global celebration of humanity's past, present and future in space.

The Yuri's Night celebration is free and open to the public. A cash bar will be available and hors d'oeuvres will be served.

All events will be held at the Courtyard by Marriott Cocoa Beach.

Visit [www.LSAworkshops.com](http://www.LSAworkshops.com) for more information and to register.

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Here are more details about Friday's KSC presentations:

In SITU – Concepts for Lunar Surface Activities

Challenges in Characterizing Low-Temperature Regolith Properties

Reducing Extra-terrestrial excavation forces with percussive

Construction on the Moon

Lunar Manufacturing

SPLITS – Small Payload Integrated Testing Services

Overview of SPLITS Line of Business at KSC

Rocket University at KSC

CubeSat Initiatives at KSC

Lab Infrastructure in support of SPLITS

Kennedy Space Center (KSC) has taken steps toward changing the culture to one of hands-on, lean engineering and innovation development with the KSC Swamp Works. Swamp Works' mission is to provide government and commercial space ventures with technologies they need for working and living on the surfaces of the moon, planets, and other bodies in our solar system.

### **ISRU**

In-Situ Resource Utilization, or ISRU, is a set of key enabling technologies to allow our nation to effectively explore the solar system, to create needed resources from regolith and the atmosphere of other planetary bodies to allow for sustainable and affordable future missions beyond LEO (low earth orbit.) The KSC Swamp Works includes the Granular Mechanics and Regolith Operations Lab and the Electrostatics and Surface Physics Lab, and fosters a culture of innovation and collaboration to make a lasting impact for NASA.

As a new focus, KSC is emphasizing its extensive capabilities in Small Payload Integrated Testing Services, or SPLITS, to apply and qualify relevant technologies, work in partnership on the creation and assembly of small satellite/cubesat applications, and provide support services to test and prepare low-cost small payload missions for accessing space or conducting future surface operations. As part of NASA's goals to support commercial space, KSC is establishing the means to facilitate collaboration and partnerships with entrepreneurs, industry, academia, and other Government entities with the goal of fostering innovation and realizing affordable, routine and reliable access to space. ##

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

[Editor: this is the start of a new feature in TTSIQ. We will be on the lookout for more such articles, and we invite readers to call such articles to our attention: [kokhmmm@aol.com](mailto:kokhmmm@aol.com) ]

### USA Moon South Pole Missions Need Acceleration

<http://www.spacecalendar.com/january-20-26-2014-vol-33-no-3-hawaii-island-usa/>

By Steve Durst,, SpaceAge Publishing Company

United States government and independent commercial missions to the next frontier of human expansion, Luna, need to accelerate. **Cislunar baseline infrastructure is a catalyst to 21st Century Solar System exploration and development.**

China's Chang'e-3 & Yutu spacecraft are now on the surface of the Moon, with a fleet of increasingly advanced siblings to follow. **India** is re-igniting its Chandrayaan Moon South Pole lander / rover project after successful flight of the indigenous heavy lift GSLV rocket. **Korea**, under the leadership of President Park Geun-hye, has declared 'landing on the Moon' a central national objective and has shortened the timeframe from 2025 to 2020.

The USA cannot afford to be left behind the rising Lunar tide. President Obama, Congress and NASA leadership need to prioritize and accelerate plans for strategic and durable Moon South Pole exploration and infrastructure development – Morpheus, Mighty Eagle and Resolve should be streamlined and deployed as rapidly as possible.

**US Government assertion of the value and importance of the Moon will open major capital finance markets to independent lunar-focused enterprises** including American teams competing in the Google Lunar X Prize – who need to finalize launch agreements in order to keep up with international competitors.

Peaceful USA-International business and cooperation in Space will benefit from **revision of complicating and harmful restrictions**. Focus and determination along with **expanding international cooperation** could see USA robotic resource-focused missions to the South Pole of the Moon by 2016-2017, with Human Moon Missions by 2019-2020." ##

**Note** that at the end of the page linked above there is a “Downrange” calendar of upcoming space-related events. This link is worth visiting regularly to keep up with what is in the works, world wide.

A direct link is <http://www.spacecalendar.com/downrange/>



Steve is also the principal mover and shaker behind the **International Lunar Observatory Association, ILOA** which supported the inclusion of the infrared telescope aboard the Chang'e 3 lunar lander, and aims at putting a similar telescope at the Moon's South Pole. <http://www.iloa.org/about.html>

Durst is also behind the series of **Galaxy Forum** educational events held around the world.

**Book Review: Safe is Not an Option:** NASA officials and others frequently emphasize the priority safety has in human spaceflight. **Jeff Foust** reviews a book that makes the argument that safety is, in fact, being overemphasized at the expense of making significant progress in space exploration. <http://www.thespacereview.com/article/2435/1>



## Lunar Ownership Laws: a Future Necessity?

[http://www.space-travel.com/reports/Lunar\\_ownership\\_laws\\_a\\_future\\_necessity\\_999.html](http://www.space-travel.com/reports/Lunar_ownership_laws_a_future_necessity_999.html)

By Boris Pavlischev, Moscow (Voice of Russia) Feb 20, 2014

Private settlements and raw materials extraction enterprises could appear on the Moon in the future, thus leading to territorial disputes between their owners. In order to avoid that one must now register the property rights to the land plots on the Moon and other space objects and set up special preservation zones, US entrepreneur Robert Bigelow believes.

The Bigelow Aerospace Company, run by American businessman, designs inflatable housing modules. In the future they will be used to build flying hotels for tourists in the Earth's orbit. A lunar base could also be built with his company's inflatable modules.

The question arises: is the owner of such a dwelling entitled to a special zone where others are not allowed to enter? Lunar industries would not be able to function without exclusive rights to a specific territory.

How/who would determine in each specific case the size of the protected territory and issue licenses to companies engaged in space related business? Bigelow is convinced that the issue of the title to property outside the Earth's orbit does not violate the Outer Space Treaty of 1967. That intergovernmental document may lead to legal collisions.

"On the one hand, there is the rule of international law, according to which space objects and their surfaces cannot be claimed by any nation. On the other hand, these documents say nothing about private use of such objects".

Nevertheless, what Bigelow now wants to hear from the American agency will become important as private astronautics develops and housing and enterprises are built on the surface of other space objects. Most likely the international treaty on outer space will have to be amended to include the activity of private entrepreneurs.

Below is the opinion of Alexander Zheleznyakov, a member of the Russian Academy of Cosmonautics.

"Private spacecraft are already flying in the unmanned mode, but soon they will be piloted. That means that people will spend more time in space. Naturally, some legal relations will occur between them as between representatives of different companies. They have to be regulated somehow".

It is better to think through these issues ahead of time and not at the last moment when everybody rushes to space and will start pushing each other, says the expert. In that sense Bigelow's addressing the Federal Agency would at least give a reason to start discussing the subject.##

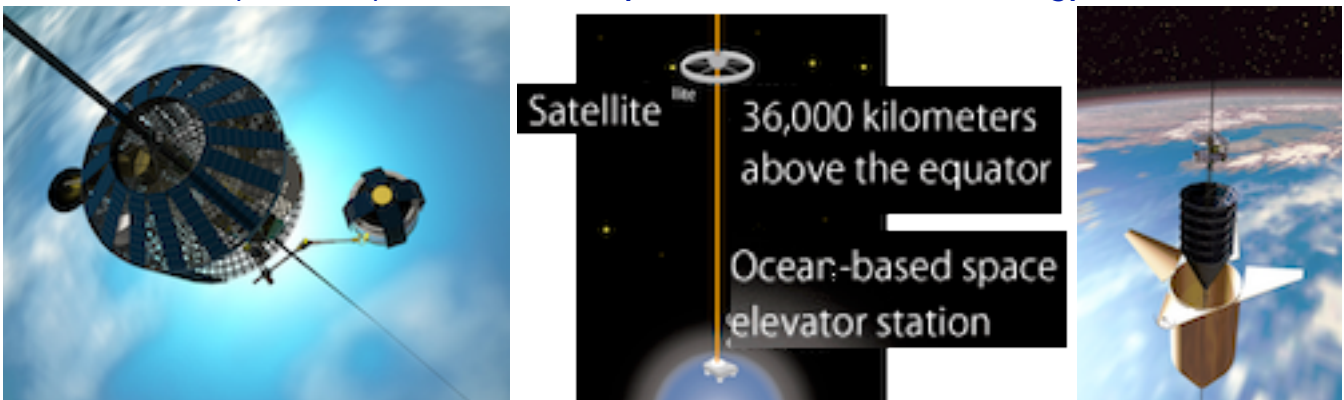
### Relevant Reading:

TTSIQ Editor's collection of **relevant articles from Moon Miners' Manifesto:**

[http://www.moonsociety.org/publications/mmm\\_themes/mmmt\\_LegalIssues.pdf](http://www.moonsociety.org/publications/mmm_themes/mmmt_LegalIssues.pdf) (76 pages)

## Can Quiet, Efficient 'Space Elevators' Really Work?

<http://www.space.com/24739-space-elevator-tether-technology.html>



February 19, 2014 Condensed version of an article by Leonard David

## Is it time to push the "up" button on the space elevator?

A space elevator consisting of an Earth-anchored tether that extends 100,000 km (62,000 mi) into space could eventually provide routine, safe, inexpensive and quiet access to orbit, some researchers say. A new assessment titled "**Space Elevators: An Assessment of the Technological Feasibility and the Way Forward**," is a study conducted by a diverse collection of experts from around the world under the auspices of the International Academy of Astronautics (IAA)

### The study produced 2 conclusions:

1. A space elevator appears possible, but risks must be mitigated through technological progress
2. A space elevator infrastructure could indeed be built via a major international effort.

A tether serving as a space elevator would be used to economically place payloads and eventually people into space using electric vehicles called climbers that drive up and down the tether at "train-like speeds". The rotation of the Earth would keep the tether taut and capable of supporting the climbers.

### Rooted in history

The notion of a beanstalk-like space elevator is rooted in history. An ahead-of-its-time "thought experiment" published in 1895 by Russian space pioneer Konstantin Tsiolkovsky He suggested creation of a free-standing tower reaching from the surface of Earth to the height of geostationary orbit (GEO; 35,786 km (22,236 mi)). Since then, writers, scientists, engineers and others have helped finesse the practicality of the space elevator. A new study marks a major development in the evolution of the idea, says IAA president Gopalan Madhavan Nair of India, formerly head of ISRO, (pronounced IZ-ro) the Indian Space Research Organization..

"No doubt all the space agencies of the world will welcome such a definitive study that investigates new ways of transportation with major changes associated with inexpensive routine access to GEO and beyond," Nair writes.

### Elevator operator

While it's always tricky to predict the future, space elevators are more than just a science-fiction fantasy. Arthur C. Clarke stated in 2003: "The space elevator will be built ten years after they stop laughing...and they have stopped laughing!"

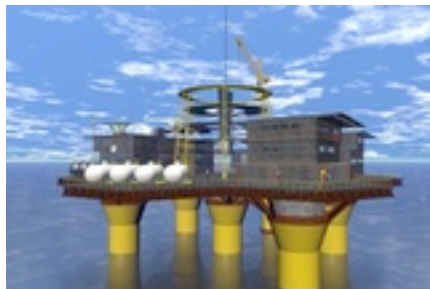
### Pacing technologies

The giggle factor regarding space elevators is "down significantly" given work carried out over the last decade by a global network of individuals and groups. But there are many, many issues to be resolved.

Two technologies are pacing the development of the space elevator:

1. Producing an ultra-strong space tether and other space elevator components has been advanced by the invention of carbon nanotubes (CNTs) that are 1,000 times better in strength-to-weight ratio than steel. The good news, he said, is that CNTs are being developed with billions of dollars by nanotechnology, electronics, optics, and materials specialists.
2. Lightweight solar cells Money, motivation and desire

Who should erect a space elevator? A primarily commercial effort with some government support is possible, as is a public-private enterprise? or an entirely governmental project?



Space elevator on an ocean platform connects Earth with space. Credit: Frank Chase/Chase Design Studios

A copy of "Space Elevators: An Assessment of the Technological Feasibility and the Way Forward" is available through Virginia Edition Publishing Company at: [www.virginiaedition.com/sciencedeck](http://www.virginiaedition.com/sciencedeck)

What about Space Elevators on the Moon?

<http://www.space.com/24905-moon-elevator-lunar-exploration-liftport.html>

<http://www.space.com/24919-lagrangian-elevator-to-the-moon-is-it-possible-video.html>

**Editor's comment:** Maybe it could be built, but it will **never** be able to handle the traffic!



## 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 individual members in many countries. The Moon Society’s **Moon Miners’ Manifesto India Quarterly** – the “older sister” to To The Stars International Quarterly, has been going to students and others in India and Elsewhere since August 2008. Older issues are available as free pdf downloads at: <http://www.moonsociety.org/india/mmm-india/>  
 With the previous issue, TTSIQ#6, that publication replaces M3IQ.

### Students for the Exploration and Development of Space – SEDS

<http://www.seds.org>

SEDS has had greater success in setting up chapters around the World than any other Space organization. How to Stars 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.

## International Space Station Crew to Connect with Virginia Students

[www.nasa.gov/press/2014/january/international-space-station-crew-to-connect-with-virginia-students/](http://www.nasa.gov/press/2014/january/international-space-station-crew-to-connect-with-virginia-students/)  
 Jan. 2, 2014 – MEDIA ADVISORY M14–001

Students in Newport News and Williamsburg, Va., will begin 2014 by talking with astronauts in orbit aboard ISS. Expedition 38 Flight Engineer Rick Mastracchio of NASA will participated in a live video chat downlink, Jan. 7, with students and educators from Denbigh High School’s Aviation Academy in Newport News. Students has the opportunity to ask hm about life, work and research aboard the station.

The downlink aired live on NASA Television and on tNASA’s Web site.

Prior to the video conference, education specialists in STEM educaton (science, technology, engineering and mathematics) Education, provided interactive learning experiences to help students gain a better understanding of the station program.

On Jan. 8, 6th grade students froma Middle School in Williamsburg, Va., connected with Expedition 38 Flight Engineer Mike Hopkins through the the Station’s Amateur Radio (ARISS) program. NASA Chief Scientist Ellen Stofan addressed the students about current research activities on the station and how a STEM curriculum could help students join the next generation of explorers. In preparation for the event, students have spent the past several weeks learning from Langley scientists, engineers, and education specialists about how the space station works and what it takes to live and work in space. ##

## Moon Mission Challenge

<http://www.innovateourworld.org/programs.htm> [unabridged]

The **Moon Mission Challenge** (MMC) has high school and middle school student teams working with Google Lunar X Prize (GLXP) competitors Astrobotic Technology, Penn State Lunar Lion, or Team Synergy Moon to design a payload based one of their lunar robotic rover missions. Starting in January 2015, teams learn about the Moon, what it takes to operate on its surface, fundamentals of payload engineering, and use that knowledge to create a payload concept which they will present at a capstone event

Students will participate in MMC through a new and exciting virtual environment, the Cyber STEM Academy. Their avatars will visit the MMC moonbase pod and engage in fun and useful content, to get themselves ready for payload design. Once they show their grasp of lunar science, exploration technology, mission history and plans, and systems engineering, they form project teams to select a payload idea based on one of several lunar missions involving robotic rovers visiting an Apollo landing site, prospecting for water ice at a lunar pole, or exploring a lunar lava tube. The teams will use their systems engineering skills to validate their payload idea, build a concept of operations, and create a business case/marketing presentation. They will have the opportunity to consult with our partner engineers as they proceed with conceptual design. Finalists will sell their idea to the MMC judges consisting of panelists from NASA, industry, space organizations, and academia, to win prizes and get a unique experience working on the cutting edge of science and technology.

Please email us at [info@innovateourworld.org](mailto:info@innovateourworld.org) for more information or visit us at the USA Science & Engineering Festival on Sunday, April 27, 2014

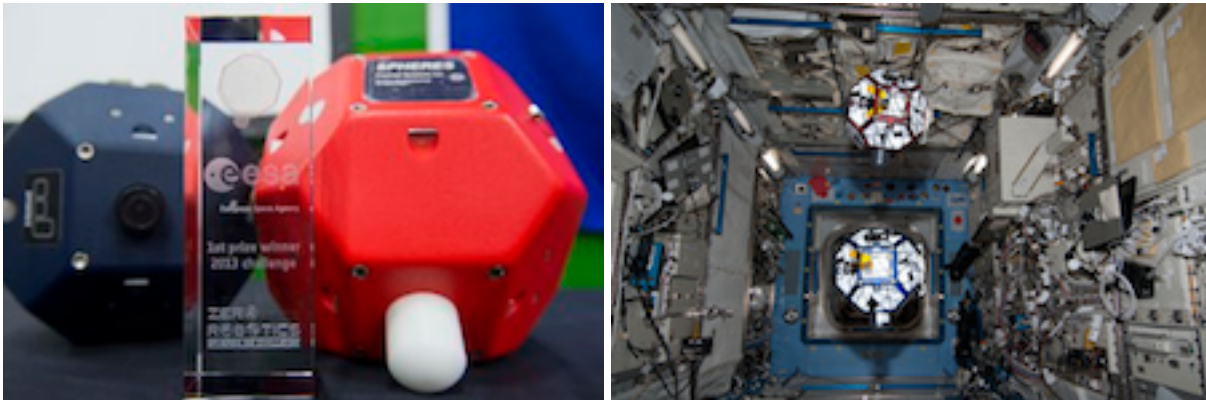
## ESA Student Exercise: Space Droids Battle to Save Earth from Comet

[http://www.esa.int/Our\\_Activities/Human\\_Spaceflight/Education/](http://www.esa.int/Our_Activities/Human_Spaceflight/Education/)

**[Space droids battle to save Earth from comet](#) - includes must-watch video aboard ISS**

21 January 2014 – **Scenario:** A comet heading towards Earth threatens humanity's existence – that was the virtual scenario of this year's **Zero Robotics** tournament. Secondary-school students from across Europe **controlled miniature satellites on the International Space Station** in a competition to save our planet.

The Space Station was turned into a playing field for the finals. The ultimate robot game challenged youngsters to write algorithms that controlled the **Spheres**, short for **Synchronised Position Hold, Engage, Reorient, Experimental Satellites**.



The Spheres are **volleyball/soccer ball-sized satellites** that hover around the Station using 12 jets powered by compressed gas. These robots have their own power, propulsion and navigation.

Friday, January 17, was the 4th time European teams ran their commands in space, and each year the competition has grown. Over **140 European students joined the US competitors, writing code to redirect an incoming comet while taking space debris and limited laser resources into account.**

The 18 teams were from **Italy, Germany, France, Spain, Romania, Belgium** and the **Netherlands**. European finalists met at the ESA Technical Centre in the Netherlands to follow the competition live from space. The US teams were connected at the Massachusetts Institute of Technology (MIT).

On the Station, NASA astronaut Richard Mastracchio and cosmonaut Oleg Kotov monitored the robotic battle. ESA astronaut André Kuipers, who monitored in 2012 from space, said "These finals are a great combination of gaming, science and technology. Robotics have a promising future to help us in orbit."



“It was fascinating to see how our code woke up the Spheres floating next to the astronauts!” said Eva Krebs, from the German team Käthe in Space. “At school our commands stayed on the screen of our computers, but this time we could see the real thing working in space.”

**Teams faced real-world challenges: ✓ loss of signal, ✓ exhausted batteries ✓tight deadlines.** Each finalist featured a three-team alliance from different European countries. Strategies to save the world

**As a virtual comet approached Earth, the satellites had to use gravitational attraction, laser repulsion or a combination of methods to change its path of planetary destruction. ##**

STORY – <http://www.ibtimes.com/nasa-sends-800-ants-iss-ants-space-program-aims-understand-insect-behavior-low-gravity-1545048>

## Students Send Ants to Space Station

<http://www.space.com/24247-students-send-ants-to-space-station-video.html>

[http://www.youtube.com/watch?v=X\\_0jIRYJ9HM](http://www.youtube.com/watch?v=X_0jIRYJ9HM)

<http://www.livescience.com/42505-students-send-ants-to-space-station-video.html>

STORY – <http://www.ibtimes.com/nasa-sends-800-ants-iss-ants-space-program-aims-understand-insect-behavior-low-gravity-1545048>

January 21 2014 – “Ants in Space” is a NASA program aimed at establishing a colony of ants on the International Space Station. In partnership with the BioServe Space Technologies Center at the University of Colorado, Boulder, scientists at NASA have successfully sent 800 ants into space in order to study how the little critters act in low-gravity environments.



Ants have developed a sophisticated system for exploring their surroundings called “distributed algorithms.” Ant colonies depend on worker ants to monitor situations and to conduct searches. Their behavior, the result of millions of years of evolution, allows ants to efficiently search for food or map new territory **by changing their foraging patterns based on the density of ants in their area.** Ants rely on smell and touching antennae to communicate with each other.

When these interactions occur frequently, ants know there is a higher density of individuals in the area, and they change their search accordingly. When ants detect fewer of their friends in a given area, they move in straight lines to cover more ground.

Why study ant behavior in space? Scientists hope to glean valuable information from the ants’ **patterns of behavior that they can apply to robotics.**

Ants have been evolving algorithms for doing (things like) this for 150 million years – what we learn from them might help us design network systems to solve similar problems.

NASA chose the common ‘pavement ant’, *Tetramorium caespitum*, usually found in households. Once on the ISS, the 800 ants were divided evenly into eight chambers, 100 in each. Engineers aboard ISS erected moveable barriers between the compartments that they could remove and replace. They record the ants’ behavior and beam the footage to scientists back on earth for analysis.

“The experiment examines whether in microgravity ants will use the rate at which they meet to assess density, and so use straighter paths in the larger habitat areas. The results will be compared to ground controls in hundreds of K-12 classrooms around the world.” ##

## A New No-Profit "Rocket STEM" Organization formed in Pensacola, FL

<http://www.rocketstem.org/>

[http://www.rocketstem.org/magazine/free\\_pdf\\_download/](http://www.rocketstem.org/magazine/free_pdf_download/)

Report by Fred Becker, NSS

RocketSTEM Media Foundation is a private, not-for-profit organization established for the purpose of fostering science, technology, engineering and mathematics (STEM) education, as well as promoting the benefits of space exploration.

Our first project is the publication of a **new magazine with content geared towards teachers, students and parents as well**. The publication blends space history - past, present and future - with interviews, career paths, astronomy lessons, aerospace and astronomy news, museum features, NASA technology spinoffs, puzzles, games, quizzes, lesson plans and other educational resources, along with easy-to-follow explanations of the mathematics and physics of all things to do with aerospace and space travel.

**As well as being free to read online, future plans include releasing each issue as an enhanced multimedia application for tablet computers such as the iPad.**



RocketSTEM Media Foundation was established in 2012. Based out of Pensacola, Florida.

The organization has volunteers located throughout the US, England and several other countries.

### **RocketSTEM' s goals are to:**

- a) Inspire the next generation of scientists, engineers and astronauts;
- b) Keep educators informed on space developments and help them better work STEM lessons into their classrooms;
- c) Raise awareness of the benefits of space exploration; and d) encourage international cooperation in space exploration.

While focused on development of the magazine at the present time, future plans include the **creation of a set of lesson plans** to be used by teachers at each grade level. During 2014 and 2015, RocketSTEM plans to endow a scholarship fund for college students pursuing aerospace studies, and for younger students wishing to attend Space Camp in Alabama or the National Flight Academy in Florida.

RocketSTEM Media Foundation is pursuing tax exempt status as a nonprofit educational organization under Section 501(c)3 of the I.R.S. tax code. The Board of Directors is comprised of Michael C. Clark, Nicole Solomon, Anthony Fitch, Timothy Brown and Brenden Clark, as of January 2013.

### **Their help-wanted page:**

<http://www.rocketstem.org/help-wanted-to-inspire-the-next-generation-of-explorers/>

Their "people" section is a lot like what I have had an idea about for the NSS website. I would like to create a "People of Space" section that profiles past and present space pioneers, as I've proposed before.

## NASA Evolves Student Rocketry Challenge

<http://www.nasa.gov/press/2014/february/nasa-evolves-student-rocketry-challenge-enhances-ties-to-space-launch-system/>

February 5, 2014 – Student teams from 26 colleges and universities in 16 states and Puerto Rico will design and launch innovative rockets and payloads as part of the 2013–2014 NASA Student Launch rocketry competition. The EVENT will be held May 15–17 at the **Bonneville Salt Flats** in Tooele County, Utah. Student teams will undergo a rigorous launch readiness review --and launch their rockets. This was the recovery site for comet and interstellar dust samples returned from NASA's Stardust mission in 2006.

"This competition ties participating students' work to NASA's pursuit of new, more demanding missions. Giving these students exposure to building and launching model rockets to 20,000 feet allows them to recognize the challenges in pushing new limits."

The student rocketry challenge is an evolution of the NASA Student Launch Projects, which for 12 years challenged students to build rockets of their own design capable of flying 1 mile high. This latest competition has even greater goals -- taking student-built vehicles more than 3 miles high.

Another new feature is the requirement that the teams build their vehicles with a parachute-based recovery system and provide three payloads able to deliver data that could shape future NASA missions.

### Three Payloads: three goals

One payload is mandatory for all teams: a landing hazard detection system, including a camera and customized software to transmit real-time information about surface conditions to operators on the ground. The teams will select the other two payloads from a list of options which support NASA spacecraft development challenges. These range from studying how liquids slosh in microgravity and refining new liquid propulsion systems, to studying the environmental effects of supersonic flight on vehicle paints and coatings. All payloads must be recoverable and reusable.

Teams must predict the maximum flight altitude of their vehicle based on the research needs of their payloads. No rocket may fly higher than 6,100 m (20,000 ft). The team whose rocket comes closest to their predicted maximum altitude will win the coveted **altitude award**.

Each team must prepare detailed preliminary and post-launch reports, and build and maintain a public website about their work, and an educational engagement program to inspire younger students in their local schools and communities.

Teams will be judged on their successful launch and payload deployment, as well as the thoroughness of supporting documentation. The winning team will receive a \$5,000 prize provided by the corporate sponsor for the rocketry challenge, ATK Aerospace Group of Promontory, Utah. NASA and ATK judges will present additional awards for winning elements of the challenge, including a safety award for the team that best integrates safeguards into their vehicle design, launch plan and ground operations.

The Student Rocket Launch continues NASA's commitment to using its space missions and programs as launch pads for engaging students in their pursuit of the vitally important STEM career fields: science, technology, engineering and mathematics.

The competition is organized by NASA's Marshall Space Flight Center in Huntsville, Ala., and sponsored by NASA's Human Exploration and Operations Mission Directorate, with corporate sponsorship by ATK Aerospace Group. For a complete list of participating teams and information about the competition, visit: <http://www.nasa.gov/education/studentlaunch>

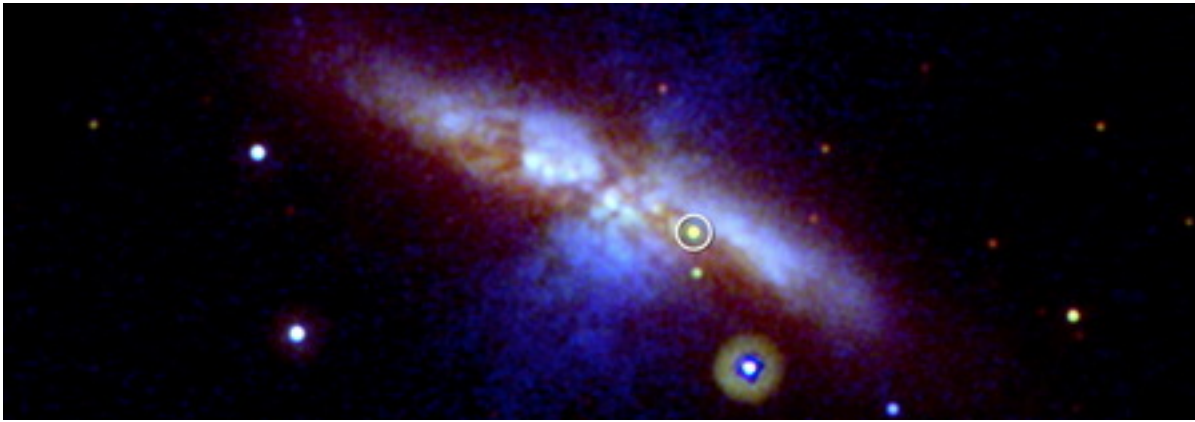
## How Students Discovered New Supernova in Nearby Galaxy

<http://www.space.com/24413-supernova-star-explosion-student-discovery.html>

Jan 26, 2014 – What started out as a 10-minute telescope lesson turned into something much more exciting, as a group of astronomy students at the University College London raced against encroaching cloud cover to document an amazing scientific discovery.

On the night of Tuesday, January 21st, astronomer Steve Fossey was showing undergraduates how to use the CCD camera on one of the observatory's automated 0.35-metre [13.7-inch] telescopes at the University of London Observatory when they spotted a star explosion in Messier 82, a nearby galaxy.

"The weather was closing in, with increasing cloud, so instead of the planned practical astronomy class, I gave the students an introductory demonstration of how to use the CCD camera on one of the observatory's automated 0.35-metre [13.7-inch] telescopes," Fossey said in a statement from UCL



NASA's Swift spacecraft captured this view of the new supernova in galaxy M82 on Jan. 22, 2014. Mid-ultraviolet light is shown in blue, near-UV light in green, and visible light in red. Thick dust in M82 scatters much of the highest-energy light, which is why the supernova appears yellowish here. **The supernova is the bright spot with a circle around it.**

Also called the Cigar Galaxy, is some 12 million light-years away and it is a popular target for small telescopes because it is bright and quite photogenic. On this particular night, M82 was also one of the few lights visible in a clear patch of the sky over London.

Fossey noticed what looked like a star overlaid on the galaxy while he was adjusting the telescope. The team checked an online archive of M82 images and found that this object wasn't there before. With more clouds rolling in, the team rushed to capture a series of 1- 2 min. exposures of the galaxy with different colored filters, and set up another telescope to check that their sighting wasn't just an anomaly.

#### Studying the new supernova

The cosmic blast occurred when a white dwarf detonated some 12 million years ago — at a time when the humans didn't exist yet — but it is so far away that the light is just reaching Earth now. But it is also one of the closest star explosions observed in modern times. The supernova [SN 1987A](#) that suddenly appeared in the sky nearly three decades ago in the Large Magellanic Cloud, a satellite of the Milky Way, is only some 168,000 light-years from Earth.

The discovery has been confirmed by the International Astronomical Union, which gave the supernova the official designation SN 2014J. The star explosion was expected to brighten through the first week of February; by then it might be visible with just a pair of binoculars.

Early observations of SN 2014J indicate it is a Type Ia supernova — the kind astronomers use as "standard candles" to measure distances across the universe because they explode with astonishingly similar intrinsic brightness.

The space agency has planned additional observations of the supernova with its other observatories, including the Hubble Space Telescope, the Chandra X-ray Observatory, the Nuclear Spectroscopic Telescope Array (or NuSTAR for short) and the Fermi Gamma-ray Space Telescope. It's possible that these instruments may find the first conclusive evidence of high-energy gamma rays and X-rays coming from a supernova. ##

### Train like an Astronaut with Waypoint 2 Space – Classes begin soon

<http://waypoint2space.com>

[ADVERTISEMENT: TO THE STARS includes the above for information purposes only, and does not endorse this or any other training program.]

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**Want to train like an Astronaut? Then Waypoint 2 Space is your first step. Registration is now open.**



## Best Telescopes for Beginners | Telescope Reviews & Buying Guide

<http://www.space.com/15693-telescopes-beginners-telescope-reviews-buying-guide.html>

There are four basic telescope types that are good for beginners: Reflector, Refractor, Hybrid and Dobsonian. This article takes look at a first-rate example of each. Read the article for details.

The editor suggests a **reflector** and/or a **Dobsonian** for beginners. The oldest type, the refractor, will be least satisfying, the “Hybrid” the most expensive.



L>R: Refractor

Reflector

Hybrid

Dobsonian

**Advice:** “if you intend to also bird-watch – or people-watch! – you’ll probably want either a Refractor or a Hybrid, because the image you’ll see can be “right-side-up” and easy to track when it moves.”

### Maintenance:

“Refractors and Hybrids are closed tubes that accumulate little dust on the optics. Reflectors and Dobsonians do take in a little dirt, but are easy enough to clean. Because air can easily circulate through, they adapt (“equilibrate”) to changing temperatures faster. That’s important to keep image distortion low.”

“Reflectors and Dobsonians also require that you manually “collimate” their mirrors from time to time. That’s not hard to do, but you still have to do it. Hybrids rarely need collimation. And Refractors never do.” Dobsonians are great for “sidewalk astronomy” and for manual rather than computer control.

Note that the vast majority of professional telescopes are **reflectors**. It is much easier to grind a large mirror than a large lens. And aperture size for aperture size, reflectors are shorter than refractors.

### Aperture (mirror or lens size):

“Aperture means “opening” in telescope-speak, and refers to the size (diameter) of the useable part of the main mirror or primary lens. E.g. 3”, 6”, 10” etc. If all else (e.g. cost, mobility, storage, etc.) is equal, wider aperture gives you sharper focus and brighter images. A telescope’s main job is actually not to magnify, but to funnel photons into your eyeball so your brain can assemble a picture. “Bigger is better.”

### Control:

Some “budget” model telescopes must be aimed by hand. More expensive ones have computer controls. Feed in the celestial co-ordinates of the object you want, and the computer calculates the coordinates in the sky, given your location and the time of day or night, then moves accordingly.

### Zooming in, or out:

Dobsonian telescopes are best if you want to look at wide areas of the sky, for example at star clusters, rather than zoom in on something small, like a planet. Some telescopes are better for wide fields of view. Others for smaller objects.

### Rent before you buy:

Renting may not be an option. If you join or visit an astronomy club for a field outing, ask to try out the wide variety of telescopes the club members may have. Tell them what in the sky interests you most – there is a considerable variety! – and try out different types and models, asking about cost. Consider the storage room you have and how portable the instrument is. The more you visit a club in the field, the better informed you will be when you decide to buy.

### To Buy or to make?

Many amateur astronomers make their own telescopes. Most of these ambitious viewers already know what kinds of objects they enjoy looking at most, and what kind of telescopes are best suited for that. Watch or help someone with experience build theirs, before trying this on your own. ##

<http://www.space.com/24135-new-telescope-stargazing-user-guide.html>

**video:** <http://www.space.com/10082-focus-telescope-tips-tricks.html>

<http://www.space.com/24740-simple-homemade-telescopes.html>

## The International Dark Skies Movement



Credit: Sean Parker | [www.sean-parker.com](http://www.sean-parker.com) | Full size image:

<http://i.space.com/images/i/000/035/695/original/milky-way-windmill-sean-parker.jpg?1388778349>

[http://en.wikipedia.org/wiki/Dark-sky\\_movement](http://en.wikipedia.org/wiki/Dark-sky_movement) - <http://www.darksky.org>

[http://en.wikipedia.org/wiki/International\\_Dark-Sky\\_Association](http://en.wikipedia.org/wiki/International_Dark-Sky_Association)

<http://www.darksky.org/night-sky-conservation/dark-sky-places>

- Communities <http://www.darksky.org/night-sky-conservation/dark-sky-places/36-ida/night-sky-conservation/88-international-dark-sky-communities>
- Parks - <http://www.darksky.org/night-sky-conservation/dark-sky-places/36-ida/night-sky-conservation/86-international-dark-sky-parks>
- Preserves - <http://www.darksky.org/night-sky-conservation/dark-sky-places/36-ida/night-sky-conservation/87-international-dark-sky-reserves>



Light pollution  
along the SE shore  
of Lake Michigan

Milwaukee 1.5 million  
Chicago 9.5 million

In the 1940s, when the writer was growing up in Milwaukee, the skies above were much, much darker and studded with stars! On the other hand, back then, any clouds above were dark, and now they are uplit with pinkish shades against a still blue sky – to be honest, a very beautiful sight!

But at the cost of masking the deeper beauty of the star-studded heavens above – hiding the fact that our world is a small island in a vast surrounding star-filled universe. Is it any wonder that so many people never wonder what is out there?

Whether we should do more than study the universe from the near end of a telescope is a question that never occurs to many, much less the thought that our destiny may lay beyond Earth's shores.

**The International Dark-Sky Association continues to accept applications from locations wishing to join in the ranks of International Dark Sky Places Program.**

Designation almost always starts with a small group of individuals who organize to seek formal protection of their night "skylines" as well as of their day "landscapes."

Designated Dark Sky areas open to communities may include both public and private lands.

**Frequently Asked Questions** - [http://www.darksky.org/assets/documents/IDSPlacesFAQ\\_May2011.pdf](http://www.darksky.org/assets/documents/IDSPlacesFAQ_May2011.pdf)

**Local Dark Sky Projects** - <http://nanaimodarksky.com> (Vancouver Island, British Columbia, Canada) with links to projects in Tucson, Arizona and Austin, Texas

**Where to start? Your local astronomy club** would like nothing better than darker skies.

If you don't have one, organizing such a club would be the way to start. **Environmentally aware persons make good allies:** lighting up the sky is a waste of energy! Now, many environmentalists are concentrated only on Earth below. Talk up the pairing of "Mother Earth" and "Father Sky!"



"Mother Earth"

"Father Sky"

It is one thing to light up the surface so we can move about safely.

It is another thing to let artificial light wash out the heavens!

We must not lose our natural right to see our star-filled "hintersky."

See "Wooing the Astronomy Community" pp. 47-8 in MMM Classics #2

[http://www.moonsociety.org/publications/mmm\\_classics/mmmc2\\_Jul2004.pdf](http://www.moonsociety.org/publications/mmm_classics/mmmc2_Jul2004.pdf)

## NASA Flying Observatory Selects Educator Teams for 2014 Science Flights

[http://www.sofia.usra.edu/News/news\\_2014/01\\_08\\_14/index.html](http://www.sofia.usra.edu/News/news_2014/01_08_14/index.html)

January 8, 2014 – NASA's Stratospheric Observatory for Infrared Astronomy, or **SOFIA**, will become a flying classroom for teachers during research flights. Twelve two-person teams have been selected for SOFIA's Airborne Astronomy Ambassadors program, with educators from 10 US states. Each will be paired with a professional astronomer to observe first-hand how airborne infrared astronomy is conducted.



L: FORECAST instrument



R: Interior view of SOPHIA in flight

**After their flight opportunities, Airborne Astronomy Ambassadors will take what they learn back to their classrooms and into their communities to promote science literacy.**

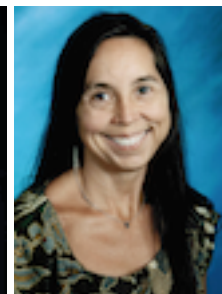
SOFIA is a highly modified Boeing 747SP jetliner fitted with a 100-inch (2.5-meter) effective diameter telescope. The aircraft flies at altitudes between 39,000 and 45,000 feet (12-14 kilometers), above the water vapor in the Earth's atmosphere, and collects data in the infrared spectrum.

SOFIA offers educator teams unprecedented access to **infrared astronomers** and the unique capabilities of an airborne observatory. Previous Airborne Astronomy Ambassadors teams have witnessed SOFIA's world-class astronomical science and have used this experience in hundreds of science, technology, engineering and math teaching opportunities throughout the United States.

Among SOFIA's Airborne Astronomy Ambassadors for 2014 is **Lynne Zielinski National Space Society, Long Grove, Ill** and a member of the **TTSIQ Editorial Team!**



L: The SOPHIA Boeing 747 aircraft



R: TTSIQ's Lynne Zielinski





## “The Survival Imperative: Using Space to Protect Earth”

By William E. Burrows – Reviewed by Ken Murphy

[www.outofthecradle.net/archives/2006/09/the-survival-imperative-using-space-to-protect-earth/](http://www.outofthecradle.net/archives/2006/09/the-survival-imperative-using-space-to-protect-earth/)

Published in 2006 by Forge Books (a Tom Doherty Associates press, like Tor Books), it weighs in at 350 pages of content plus several appendices. No errors noted.

Mr. Burrows, a [professor of Journalism at NYU](#), is one of the better known chroniclers of the space age, and his book “This New Ocean” is a particularly well known title. In “[The Survival Imperative](#)”, Mr. Burrows picks up on the growing theme of “Space for the benefit of Earth”, and lays out a very compelling case for why our efforts to develop the space frontier are not merely a luxury, but rather a necessity if we value the continuity of our civilization into the indefinite future.

In the first chapter, “Hell on Earth”, Mr. Burrows lays out the entirely plausible scenario of a ‘string of pearls’ cometary impactor laying a line of destruction from the Indian subcontinent to the Great Lakes in North America. The scenario is that the impactor is a ‘blindsider’ [my term], coming up out of the Sun’s gravity well where our telescopes can’t espy them and at a speed that makes the  $F=ma$  formula not our friend. In the aftermath, the Indian subcontinent becomes a nuclear inferno, 3.5 million people die in NYC, and the chaos that ensues as social order breaks down and a cloud of impact debris and radioactive fallout begins to spread over the planet. It is not a fun chapter, though Mr. Burrows lays it all out in a calm and journalistic manner. It’s not a ‘Doomsday scenario’ harangue, but more a documentation of what would occur. Nevertheless, the particularly sensitive in spirit might want to avoid that chapter.

In the next chapter, “Let there be light,” the author explains how we already have most of the tools we need to start addressing these risks in an effort to mitigate them. (Only a fool believes that risk can be ‘eliminated’). ‘Light’, in this context is the light of knowledge, that wonderful human achievement that underlies our civilization and has provided us the means to create these tools. He also explores how the light of knowledge can be turned into a tool of darkness.

He continues on that theme in “Target Earth”, as he lays out the myriad self-inflicted ways in which humanity can do itself in, as well as how Mother Earth has her own particular indifference to our existence. This is another tough chapter, made worse by the fact that these are the things we do to ourselves. But he also starts laying out how we’ve started deploying space tools to help us address these risks.

In the next chapter, “The Once and Future Space Program”, the author walks us through a brief history of modern space, from Tsiolkovsky’s first realistic treatments on the subject to the modern mess that is NASA as an institution. In the next chapter, “A beehive called Earth”, he lays out the how we’ve developed our cislunar assets: the communications, reconnaissance, spy, TV, radio, GPS and other satellites, and how these assets have changed our lives. Next up is the people in “The Ultimate Frequent Flier Program” where Mr. Burrows explores some of the concepts that have been promulgated for people to go into space to stay. He ends by calling for a Planetary Protection Program as the overall mission and strategy for NASA’s efforts.

My favorite chapter is of course “A Treasure Chest on the Moon”. It is here that he lays out his case for an [ARC on the Moon](#), an archive of our civilization, or better, a back-up hard drive of our knowledge. I saw a presentation of this by Mr. Burrows at an NSS-NYC meeting back in 2000 back before I left for [ISU](#). Ever since I’ve been convinced of the merits of the idea, though I think the asteroid watch is a much more important idea and its that one that made it into my [“25 Good Reasons to go to the Moon”](#) (#14 – Neighborhood Watch). It’s also the last chapter of the book, “The Guardians”. Here is where he makes his case that the only way we can ensure that our civilization doesn’t slip into animalistic barbarism in the event of catastrophe is to spread the pieces of our civilization around not just our planet, but also our Solar system. Part of that is providing tools for a better understanding of our home environment.

This is a book that should be required of our policymakers, and encouraged of our public figures. Someone should send a copy to Oprah. This book lays out a compelling need for, and a way to address, a program of protecting our home planet from threats both internal and external. It is not a ‘doom and gloom’ handbook, but rather a rational laying-out of what the current situation is in this regards. It’s actually optimistic in that he rightfully acknowledges that the United States can play a significant technical and leadership role in this project, though really it is a global project (and we haven’t necessarily been showing ourselves to be playing well in that regard). The author has done a lot of homework, as demonstrated in the extensive bibliography, and also includes some documents that have previously been sent to policymakers in an attempt to draw their attention to this important aspect of our existence on this planet. This one gets a Full Moon rating. KM



## A Letter from Lynne Zielinski to Teachers and Students

### To Those Teachers and Mentors that Accompanied Their Students To the 2014 International Space Development Conference:

I very much appreciate your support of the students coming to the United States to participate in the Space Settlement Design Competition and to attend the International Space Development Conference of the National Space Society. I was delighted to be able to share the experience of the docking of the first commercial Dragon spacecraft with our guests while NASA administrator Charles Bolden spoke at our plenary session and it was a pleasure to see and meet so many creative and enthusiastic students from around the world. NSS is happy to use this occasion to introduce to you the new electronic publication, *To The Stars International Quarterly* (TTSIQ) and to make some additional announcements.

The NSS Board of Directors has offered a complimentary one year NSS membership to the students, teachers, and mentors that participated in our 2014 ISDC conference in Los Angeles, CA. For those who wish to take advantage of the membership offer, please contact me at [nss-students@nss.org](mailto:nss-students@nss.org) to gain access to a form. In the form, you will need to provide some personal information for our NSS membership database. This information will not be shared with other organizations. Persons submitting this information will have a one year membership beginning the date of submission and will also receive a one year subscription to the NSS electronic version of *Ad Astra* magazine.

We would also like to inform those students and teacher wanting to form an NSS student chapter to know that all it takes to begin are three NSS members and the consent and participation of a teacher or other adult individual connected with the sponsoring school or student group. Chapter starting kit information is provided in this issue of *To The Stars International Quarterly*. One way that all the chapters will keep in touch, is through TTSIQ. This will be the place to share news about what is happening around the world in space and to give students and teachers an opportunity to use this publication to report on what is happening in your chapter and in you your country.

I hope to see many of you return to the 2015 ISDC, to be held in Toronto, Ontario, Canada. **Note:** Please monitor the National Space Society 2014 ISDC Student Website for Current Updates and New Information - <https://sites.google.com/site/isdcforstudentcompetitions/> NEW CONTACT EMAIL - [nss-students@nss.org](mailto:nss-students@nss.org)

#### **New Student Opportunities and Activities at ISS:**

- NSS Roadmap Graphics & Poster Contest
- Be a "To The Stars International Quarterly" On-line Publication Writer or Editor
- Attend the 'How To Start A Chapter Workshop' for Teachers
- Attend the "International Forum" to become involved in international space issues.
- Attend the "Chapter Activities Share-A-Thon" and workshop
- Organize and get involved in our new space social network

NSS is reaching out to you to become active in making Space all our nations future!!!

Ad Astra, Lynne F. Zielinski, NSS Director & VP of Public Affairs, NSS Education & Outreach Chair

## NEW NATIONAL SPACE SOCIETY INTERNATIONAL STUDENT CHAPTER STARTING KIT

From Karen Mermel, National Space Society International Committee

[kmermel@yahoo.com](mailto:kmermel@yahoo.com)

- The National Space Society has prepared a brand new International Student Chapter Starting Kit.
- This will be emailed to those students who attended the ISDC last May (2012) and who gave us their email addresses.
- If you don't receive one, and would like to start a chapter in your school, send your email address, name and country to [kmermel@yahoo.com](mailto:kmermel@yahoo.com) requesting a chapter starting kit.
- Give us about 2 weeks before you write us.
- Getting the Kit does not mean that you have to start a chapter, but it will give you information about what is needed if you wish to do so.

#### **Note from Editor to Students:**

If you get your copy of *To The Stars International Quarterly* through your teacher, but would like to get it directly, or want to make sure you get TTSIQ after you graduate from your class, **send your personal email address** to Karen Mermel, who maintains the TTSIQ email list, at [kmermel@yahoo.com](mailto:kmermel@yahoo.com)

## List of Recent Feature Articles and Essays in Our Sister Publications



**Ad Astra** [Latin (ancient Roman): "To The Stars"] <http://www.nss.org/adastra/>  
 Sent to all National Space Society Members as a primary membership benefit  
 (with choice of print hardcopy or downloadable pdf file)

**SPRING 2014 issue** – (Ed. a 5–star must read issue)

**Inspiration Mars** by Clifford McMurray

**Interstellar Space Settlement Made Easy** by Mark Hopkins

**Milestones to Space Settlement: An NSS Roadmap\*** 24 page document with input from many minds!

- I. Introduction
- II. Milestones to all Destinations
- III. Utilization of Space Technology and Resources
- IV. To the Moon
- V. To Mars
- VI. To the Asteroids
- VII. To Orbital Space Settlements
- VIII. To the Stars

**The Colonization of (near) Space** by Keith Henson and Steve Nixon  
**Roadmap to Space Art Contest**



Ten issues a year since December 1986 [MMM is not published in January or July]

[www.MMM-MoonMinersManifesto.com](http://www.MMM-MoonMinersManifesto.com)

Produced by the Milwaukee Lunar Reclamation Society, chapter of NSS

<http://www.Milwaukee-Lunar-Reclamation.org>

Sent to all Moon Society Members as a primary membership benefit  
 (choice of print hardcopy or downloadable pdf file)

And also, by contract, to members of 8 NSS Chapters, and individual subscribers

**FEBRUARY 2014 – MMM #272**

- 2 In Focus: Creating a Manufacturing “Beachhead” on the Moon, Peter Kokh
- 5 Growing “Start-up” Industries on the Moon, Dave Dietzler
- 6 “Backing up” our Civilization, Peter Kokh

**MARCH 2014 – MMM #273**

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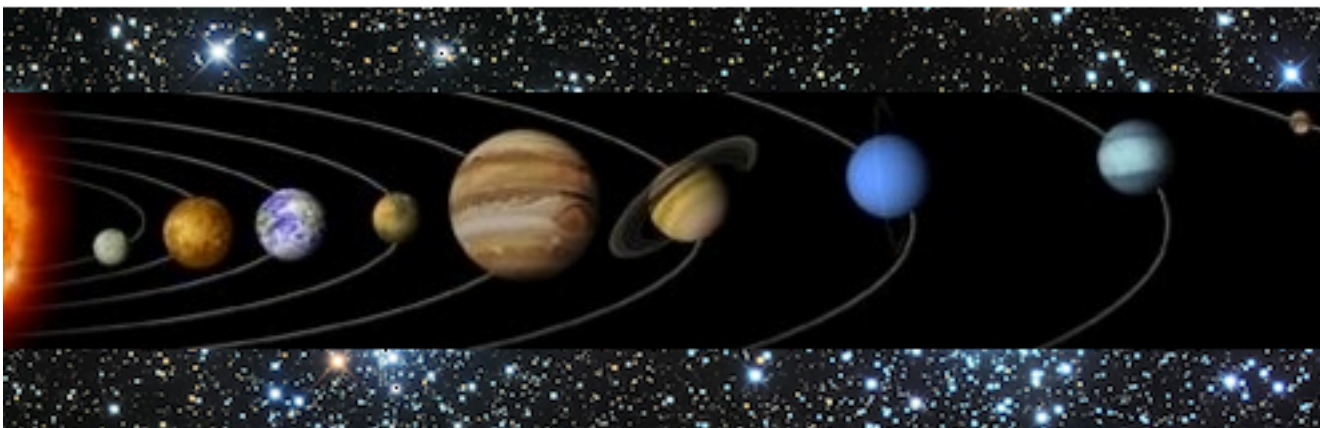
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