Reducing space transportation costs considerably is vital to achievement of mankind's goals & dreams in space

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 varing 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 Moon Miners' Manifesto – http://www.moonsociety.org/chapters/milwaukee/mmm/

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.

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. Astepped program of robotic missions, thena 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

This issue is online at: www.moonsociety.org/international/ttsiq/ **and at:** www.nss.org/tothestars/

SPACE TOURISM

Virgin Galactic's Private Spaceship Offers Enticing Science Opportunities

http://www.space.com/22024-**virgin-galactic-spaceshiptwo-suborbital-research**.html

[Editor's summary. For the full article see the link cited above]

July 19, 2013 - With all the attention being given to Virgin Galactic's impressive list of future celebrities, its spaceship's impressive capabilities for microgravity research have been largely overlooked.

The private space plane, SpaceShipTwo, is set to begin carrying passengers to the edge of space on suborbital rides in 2014. Some 600 people have already signed up for flights, including famous actors and singers, and Virgin Galactic's celebrity founder himself, Sir Richard Branson.

SpaceShipTwo has 14 cubic meters) (500 cubic feet) of interior space available for experiments. The passenger cabin can fit the equivalent of 20 space shuttle mid-deck locker equivalents as well as a flight test engineer who to run experiments. In total, SpaceShipTwo can carry 600 kg (1,300 lb) to an altitude of up to 110 km (361,000 ft), where experiments will experience 3-4 minutes of microgravity.

For researchers who do not need to go all the way to space, SpaceShipTwo's mothership, WhiteKnightTwo, will be capable of carrying up to (30,000 lbs) 13.6 metric tonnes 15 tons) of payload to altitudes higher than15 km (50,000 feet) and linger for extended durations.

The mid-deck locker equivalents and cargo transfer bags are the smallest-sized units used to house experiments on SpaceShipTwo. Each can hold up to 50 lbs (22.68 kg) [see link for bag sizes]

The cost per payload will vary depending upon several factors: size and mass of your experiment, the relative complexity of approving the payload for flight and of physically integrating it into SpaceShipTwo, and any special requirements that affect flight time or flight profile, according to Virgin Galactic's payload users guide. Flying a simple, non-hazardous single cargo transfer bag or mid-deck locker payload would run around $50,000, according to the guide.

"We would be open to allowing different experimenters to share the space of a middeck locker (or cargo transfer bag, et cetera)," Pomerantz said. "Additionally, there may be third party payload integrators that offer this as a service."

Research missions will begin one to three months after the first commercial passenger flight takes place, which is now scheduled for sometime in 2014. Mixed tourism/research flights would begin the first year after commercial service begins. Chartered research missions by single users and shared flights purchased by multiple experimenters would commence 18 months after the maiden commercial voyage.

High-altitude research missions aboard WhiteKnightTwo are scheduled to begin in 2016. That same year, the company's orbital rocket, LauncherOne, is set to make its debut. The vehicle will be launched from midair by WhiteKnightTwo. ##

Record-Breaking SpaceShipTwo Test Flight - Passenger Trips By 2014

September 6, 2013 - http://www.space.com/22669-virgin-galactic-spaceshiptwo-test-milestones.html

www.space.com/22664-spaceshiptwo-tests-rocket-engine-again-in-2nd-powered-flight-**video**.html

[Editor's summary. For the full article see the link cited above]

Virgin Galactic's Spaceship 2 flew higher and faster than it ever had before on September 5th, boosting confidence that the vehicle can start carrying passengers on suborbital jaunts next year.

The Spaceport Terminal seems ready for business - http://www.thespacereview.com/article/2363/1

In its second-ever rocket-powered test flight from the Mojave Air and Space Port in California, SpaceShipTwo reached a maximum altitude of 19,800 m (65,000 ft) and a top speed of Mach 1.6. Its previous record was 17,000m (56,000 ft) and Mach 1.2 on April 29. Its engine burned for 16 seconds during that first test, compared to 20 seconds on this flight.

The craft also demonstrated its unique re-entry mechanism during, rotating its wings and tail upward into a "feather" for a slow and steady descent. The vehicle had done this previously on unpowered without a rocket firing. This flight demonstrated a longer burn duration and robust testing of the feather mechanism, supersonic aerodynamics and wing lift structure," Virgin Galactic CEO George Whitesides said "Each powered flight of SpaceShipTwo yields cumulative progress that builds the foundation for safe and exciting commercial spaceflights." "We are on track for a 2014 start of commercial service," Virgin Galactic founder Branson said. He and his family will be on SpaceShipTwo's maiden commercial voyage.

SpaceShipTwo is carried aloft by a plane called WhiteKnightTwo, which drops the vehicle at an altitude of about 15,000 m (50,000 ft). The spaceship's rocket engine kicks in at that point, blasting the vehicle into suborbital space. Passengers won't complete a full orbit of Earth, but they will get a few minutes of weightlessness and a view of our planet against the blackness of space.

SpaceShipTwo was built by the aerospace firm Scaled Composites, which also constructed the vehicle's predecessor, SpaceShipOne. SpaceShipOne won the $10 million Ansari X Prize in 2004 after becoming the first private craft to fly people to space and back twice in the span of a week.

TO THE EDGE OF SPACE

Human Spaceflight Research: ESA's Envihab

www.esa.int/Our_Activities/Human_Spaceflight/Human_Spaceflight_Research/Changing_environments

Envihab Gravity Machine

[Editor's summary. For the full article see the link cited above]

July 5, 2013: The European Space Agency's interest in how astronauts react to living in weightlessness and how to keep fit without the benefit of gravity took a step forward today with the opening of the new 'Envihab' in Cologne, Germany.

One way of studying astronauts' responses to the absence of gravity in space, here on Earth, is to subject volunteers to prolonged stays in bed, with their feet slightly up. The German Aerospace Center has built Envihab to host bedrest studies and to answer as many questions as possible about the human body.

Aside from state-of-the-art monitoring equipment such as MRI scanners, the building offers scientists complete control of the volunteer's environment. At the flick of a switch, scientists can change the type of lighting, the air pressure and even the amount of oxygen the volunteers breath during their stay.

Envihab's centrifuge can put volunteers under hypergravity, up to 12 Gs. Exercise bicycles and other machines can be installed in the centrifuge to test techniques for keeping fit in space. A robotic arm can monitor the volunteer's arteries via ultrasound – the first in its kind.

Will tinted blue light or reduced air pressure help astronauts to better adjust? What type of exercise is best for preserving bone strength? The possibilities for examinations are endless and the answers are important for spacecraft designers and mission controllers, as well as for architects and hospital staff.

According to Rupert Gerzer, director of the centre's institute of aerospace medicine, "No other facility in the world has all the equipment that Envihab offers to scientists in a single place. The goal is to answer as many questions we have on the human body as possible."

The first bedrest study to be conducted at Envihab is planned for 2014. ##

Space Laser To Prove that Increased Broadband is Possible

http://www.spacedaily.com/reports/**Space_Laser_To_Prove_Increased_Broadband_Possible**_999.html

[Editor's summary. For the full article see the link cited above]


LADEE Satellite in lunar orbit

September 3, 2013 - When NASA's **Lunar Laser Communication Demonstration** (LLCD) begins operation aboard the Lunar Atmosphere and Dust Environment Explorer (LADEE) mission, it will attempt to show that 2-way laser communication beyond Earth is possible, expanding the possibility of transmitting huge amounts of data. This could one day allow routine 3-D High Definition video transmissions in deep space.

"The goal of the LLCD experiment is to validate and build confidence in this technology so that future missions will consider using it," said Don Cornwell, LLCD manager. MIT (Massachusetts Institute of Technology Lincoln Laboratory) developed this technology that has incredible application possibilities.

Since NASA first ventured into space, through the Moon landings, shuttle program, and unmanned exploration missions, radio frequency communication also known as RF, has been the communications platform used. **RF is reaching its limit** just as demand for more data capacity continues to increase. The development of laser communications will give NASA the ability to extend communication applications such as increased image resolution and even 3-D video transmission into deep space.

[Editor: Could it make tele-presence robotic operations more feasible as well?]

LLCD is NASA's first dedicated system for two-way communication using laser instead of radio waves. "LLCD is designed to send **six times more data from the Moon** using a smaller transmitter with 25 percent less power as compared to the equivalent state-of-the-art radio (RF) system. Lasers are also more secure and less susceptible to interference and jamming.

The LLCD experiment is onboard NASA's LADEE: a 100-day robotic mission to confirm whether or not dust caused a mysterious glow on the lunar horizon astronauts observed during several Apollo missions and explore the Moon's tenuous, exotic atmosphere.

LLCD's main mission objective is to transmit hundreds of millions of bits of data per second from the Moon to Earth. This is equivalent to transmitting more than 100 HD television channels at once. LLCD receiving capability will also be tested as tens of millions of bits per second are sent from Earth to the spacecraft. The experiment will prove that increased bandwidth technology for future missions is possible.

The primary ground terminal is at NASA's White Sands Complex in New Mexico. The team at MIT designed, built, and tested the terminal. They also will be responsible for LLCD's operation at that site. There are two alternate sites, one located at NASA's Jet Propulsion Laboratory in California, for receiving only. The other is being provided by the European Space Agency on the Spanish island of Tenerife, off the coast of Africa. It will have two-way communication capability with LLCD. "Having several sites gives us alternatives which greatly reduces the possibility of interference from clouds," said Cornwell.

LLCD is a short duration experiment and the precursor to NASA's long duration demonstration, the Laser Communications Relay Demonstration (LCRD). It also is a part of the agency's Technology

Demonstration Missions Program, which is working to develop crosscutting technology capable of operating in the rigors of space. LCRD is scheduled to launch in 2017.

NASA engineers believe this technology becomes even more advantageous for communications beyond Earth's orbit with probes en route to Jupiter, Mars, and Mercury. Recently, an image of Leonardo da Vinci's painting, the Mona Lisa, was transmitted to NASA's Lunar Reconnaissance Orbiter (LRO) spacecraft orbiting the Moon at only hundreds of data bits per second. "LLCD will be the first dedicated optical communication system and will send data millions of times faster."

ESA has already successfully demonstrated laser communication between satellites in Earth orbit. Recently they launched Alphasat to demonstrate laser transmission between a low-Earth orbit satellite and a satellite in geostationary Earth orbit. LLCD's laser link from the Moon will be ten times farther away. ##

Chinese Rocket Engine Test a Big Step for Space Station Project

http://www.space.com/21957-**china-rocket-engine-test-space-station**.html

[Editor's summary of an article by Leonard David. For the full article see the link cited above]

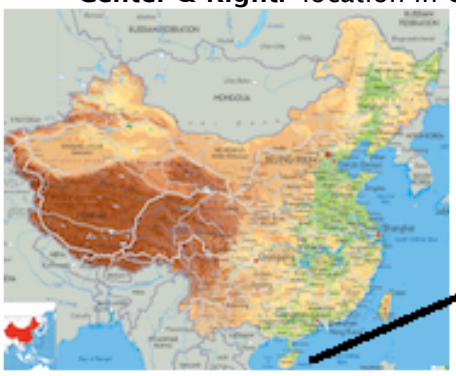
China has successfully test-fired the rocket engine that will power the next-generation heavy-lift booster, the Long March 5. The first engine test on June 29 lasted about three minutes from ignition to shutdown. The new rocket engine is needed to boost into orbit component for China's planned space station, and will a big step forward for China's moon exploration program.

The Long March 5 is one of China's new generation of rockets with larger carrying capacities. China is drawing up plans fora medium-size Long March 7. The Long March 5 will be mainly used for the lofting China's manned space station - it can carry a 18 metric tons (20-ton) payload to near-Earth orbit.

http://i.space.com/images/i/000/012/419/original/**china-space-station-design-art**.jpg?1317293883

China's planned Long March 7 booster can place 12 metric tons (13 tons) into Earth orbit, and is designed to launch cargo spacecraft to the planed space station. A new Tiangong 2 space laboratory will be in orbit by 2015, to further sharpen the skills and technologies needed to build a larger space station. China would then launch an experimental core module of the larger space station in 2018. By 2020, the planned station should be complete, as now foreseen.

Below left: China's planned Space Station **Center & Right:** location in China and on Hainan I.



The Long March 5 and Long March 7 boosters will launch from the Wenchang Satellite Launch Center, which is currently under construction on the NE coast of Hainan Island. This will be the fourth space launch facility in China, after Jiuquan, Taiyuan and Xichang launch complexes.

Left: http://i.space.com/images/i/000/002/235/original/h_china_longmarchseries_02.jpg?1292265282

China has developed a family of boosters over the years, including new development of a heavy-lift launcher to fly by 2011 - Video link: http://www.space.com/21938-**china-test-fires-new-heavy-lift-rocket-engine-video**.html

Right: http://i.space.com/images/i/000/030/823/i02/china-long-march-5launch-animation.jpg?1373889530

The total cost of the launch-center project was estimated to be RMB 5 billion Chinese ($810 million). Once in operation, the Hainan complex will launch heavy geostationary telecommunications satellites, support missions for the construction of China's space station and help further the country's lunar exploration agenda. Meanwhile, piloted space missions will continue to be conducted from the south launch site at the Jiuquan Satellite Launch Centre.

Radical, unnoticed shift

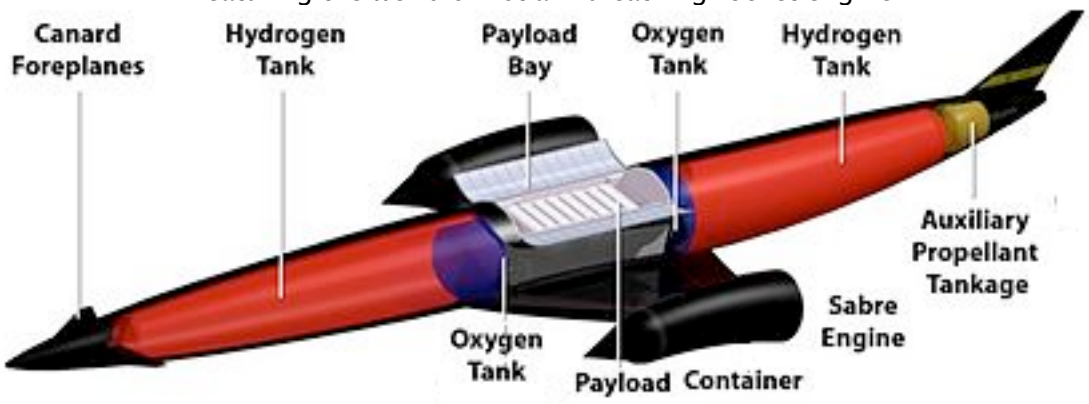
China's space progress has been closely watched by Gregory Kulacki, a senior analyst and China project manager within the U.S.-based Union of Concerned Scientists' Global Security Program. "In addition to supporting a new generation of Chinese space launch vehicles that will greatly expand China's capability to carry larger and heavier spacecraft into Earth orbit and beyond, the opening of the new launch facility on Hainan Island next year will mark a radical and largely unnoticed shift in the culture of the Chinese space community," Kulacki told SPACE.com.

The new Hainan facility is planned as a future Mecca for middle-class Chinese tourists, surrounded by coconut groves, a beach resort, museums and an amusement park. "Its completion will mark the beginning of a transition for China's space culture, from the cloistered preserve of specialists employed by the military to a more commercial and entrepreneurial enterprise that is open to the general public." ##

Update on the Skylon Project

http://www.reactionengines.co.uk/news_updates.html - http://en.wikipedia.org/wiki/Skylon_(spacecraft)

Featuring the world's first air-breathing rocket engine

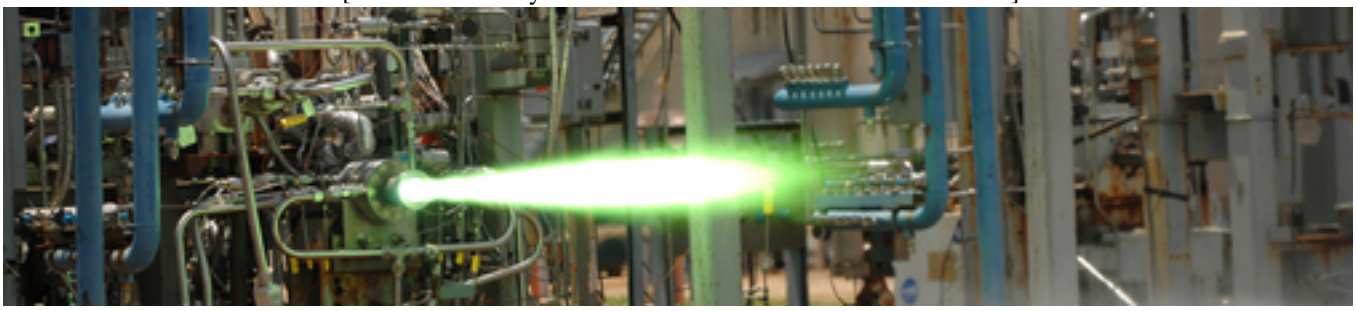


For Skylon enthusiasts: http://www.reactionengines.co.uk/tech_docs/**SKYLON_User_Manual_rev1-1**.pdf

3D-Printed Rocket Parts Excel in NASA Tests

http://www.space.com/22119-**3d-printed-rocket-part-test**.html

[Editor's summary. For the full article see the link cited above]



A 3D-printed rocket engine injector undergoes hot-fire testing at NASA's Marshall Space Flight Center in Alabama, during which it was exposed to temperatures of nearly 6,000 degrees Fahrenheit.

Video: www.space.com/22098-**3-d-printed-rocket-injector-works-in-hot-fire-test-video**.html

Key rocket parts built with 3D-printing technology have passed another round of NASA firing tests, inspiring further confidence among space agency officials in this emerging manufacturing technique. Two

rocket engine **injectors made with a 3D printer performed as well as traditionally constructed parts during recent hot-fire tests**, which exposed them to temperatures approaching 6,000 degrees Fahrenheit (3,316 degrees Celsius) and extreme pressures, NASA announced on July 24. The recent tests at Marshall Space Flight Center in Huntsville, Ala., followed closely other successful hot-fire trials of 3D-printed engine injectors conducted at the NASAs Glenn Research Center in Cleveland, Ohio.

Left: 3-D printed rocket injector as it looked immediately after it was removed from the laser melting printer.
Right: Injector after inspection and polishing

Cost reduction and telescoping time from design to production are goals.

"Rocket engines are complex, with hundreds of individual components that many suppliers typically build and assemble, so testing an engine component built with a new process helps verify that it might be an affordable way to make future rockets. The additive manufacturing process has the potential to reduce the time and cost associated with making complex parts by an order of magnitude," said Chris Singer, director of Marshall's engineering directorate. The injectors' performance was identical to that of traditionally manufactured parts already tested during the development of NASA's Space Launch System rocket (SLS), a heavy lifter].

- Traditionally constructed injectors used in SLS tests cost c. $10,000 each and took 6 months to build.
- The 3D-printed versions cost less than $5,000 and reached the test stand in a matter of weeks.

NASA sees great promise in 3D-printing technology. "At NASA, we recognize ground-based and in-space additive manufacturing offer the potential for new mission opportunities, whether printing rocket parts, tools or entire spacecraf. Additive manufacturing will improve affordability from design-and-development to flight-and-operations, enabling every aspect of sustainable, long-term human space exploration."

In To The Stars International Quarterly #4, released July 6th, we reported on NASA's plans to bring a 3D printer to the International Space Station, and to use it to "print" pizzas and other food items that will greatly improve astronaut dining.

- http://www.space.com/21630-3d-printer-space-station-tests.html
- http://www.nasa.gov/directorates/spacetech/home/feature_3d_food_prt.htm
- http://www.space.com/21250-nasa-3d-food-printer-pizza.html
- http://news.techworld.com/personal-tech/3461464/nasa-to-launch-a-3d-printer-into-space-and-use-it-on-iss/

NASA Tests "Game Changing" Composite Cryogenic Fuel Tank

http://www.spacedaily.com/reports/prnewswire-space-news.html

[Editor's summary. For the full article see the link cited above]

WASHINGTON, July 2, 2013 /PRNewswire-USNewswire/ -- NASA recently completed a major space technology development milestone by successfully testing a pressurized, large cryogenic propellant tank made of composite materials. The composite tank will enable the next generation of rockets and spacecraft needed for space exploration.

Cryogenic propellants are gasses chilled to subfreezing temperatures and condensed to form highly combustible liquids, providing high-energy propulsion solutions critical to future, long-term human exploration missions beyond low-Earth orbit. Cryogenic propellants, such as liquid oxygen and liquid hydrogen, have been traditionally used for large rockets and NASA's space shuttle.

The almost 2.4 m (8 ft) diameter 8°C (-423°F) and underwent 20 pressure cycles as engineers changed the pressure up to 9.5 kg per cm2 (135 psi).

Testing experience with the smaller tank is helping NASA perfect manufacturing and test plans for a much larger tank. The 5.5 m (18 ft) tank will be one of the largest composite propellant tanks ever built

and will incorporate design features and manufacturing processes applicable to an 8.4 meter (27.5 foot) tank, the size of metal tanks found in today's large launch vehicles. .

The tank manufacturing process involve two industry breakthroughs:

- automated fiber placement k oven-cured materials
- fiber placement of an all-composite tank wall design that is leak-tight and a tooling approach that eliminates heavy-joints. (Composite tank joints, especially bolted joints, have been a particularly troubling area prone to leaks in the past.) Boeing and its partner, Janicki Industries of Sedro-Woolley, WA developed novel tooling to eliminate the need for heavy joints.
- a 40% weight savings in rocket fuel tanks

"Game changing is about developing transformative technologies that enable new missions and new capabilities. Technological advances like the cryogenic tank can ripple throughout the aerospace industry and change the way we do business." said Stephen Gaddis, the program manager for the Game Changing Development Program at NASA's Langley Research Center in Hampton, Va.

Video on NASA's composite cryogenic tank work: https://www.youtube.com/watch?v=IRutJfOsgII

Related story: NASA Announces Advanced Composite Research Partnership

www.nasa.gov/press/2013/september/nasa-announces-advanced-composite-research-partnership/

WASHINGTON, Sept. 23, 2013 - RELEASE 13-293 - NASA has selected six companies from five U.S. states to participate in a government-and-industry partnership to advance composite materials research and certification.

The companies are:

- Bell Helicopter Textron Inc. of Fort Worth, Texas
- GE Aviation of Cincinnati
- Lockheed Martin Aeronautics Company of Palmdale, Calif.
- Northrop Grumman Aerospace Systems of Redondo Beach, Calif.
- Boeing Research & Technology of St. Louis
- United Technologies Corporation and subsidiary Pratt & Whitney of Hartford, Conn.

LOW EARTH ORBIT

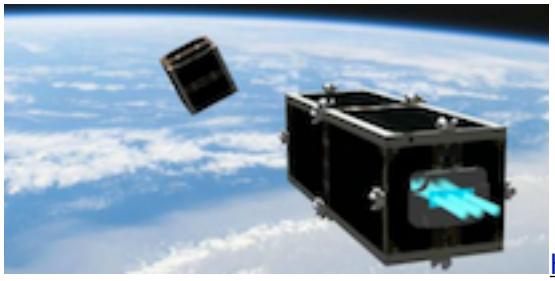
Europe's Largest-Ever Telecom Satellite Launches With Indian Weather Probe

http://www.space.com/22134-**ariane5-rocket-launch-india-satellites**.html

[Editor's summary. For the full article see the link cited above]

London-based mobile satellite services operator Immarsat, said its Inmarsat I-4A F4, the first satellite using the Alphabus platform developed by the French and European space agencies, was sending telemetry data. The 6,650-kilogram I-4A F4 will operate a contracted 15 years from 25°E to expand the amount of L-band spectrum Inmarsat has at its disposal with its existing fleet.

The Alphasat satellite also carried 4 technology demonstration payloads for ESA. India's Insat-3D weighed 2,120 k at launch and should operate for seven years from 82 °E in geostationary orbit. It carries a 6-channel imager and a 19-channel sounder instrument, the latter designed to take vertical profiles of atmospheric humidity, temperature and ozone levels. It also carries a search-and-rescue transponder to relay distress signals from maritime, aeronautical and terrestrial beacons to alert rescue centers.



http://www.isro.org/insat-3d/pdf/**insat-3d-brochure**.pdf

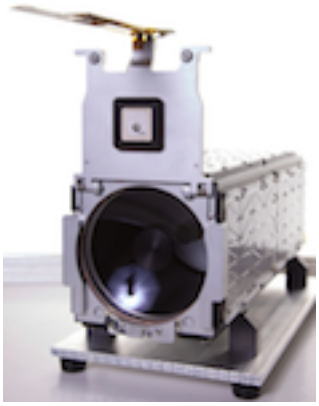
India's Insat-3D meteorological satellite uses ISRO's veteran I-2K satellite bus, the same one used on many Indian telecommuni-cations satellites. When ready, India's new GSLV, or Geostationary Satellite Launch Vehicle will carry satellites to geostationary orbit. But until then, India continues to rely on the Ariane 5, whose next flight, set for Aug. 29, will carry ISRO's GSAT-7, a UHF-, S-, C- and Ku-band telecommunications spacecraft to operate from 74°E in geostationary orbit. ##

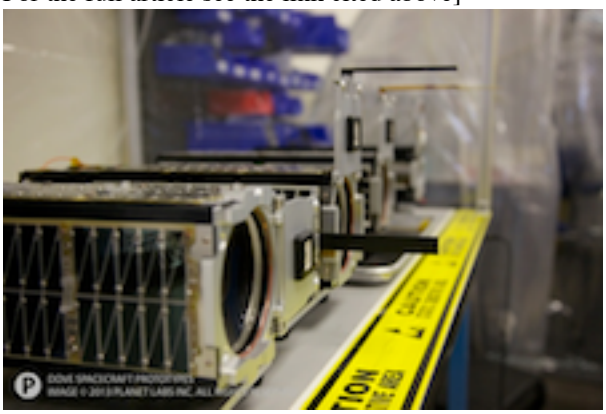
CUBE SATS – also see Student-Teacher area below

Planet Labs Unveils Tiny Earth-Observation Satellite Family

http://www.space.com/22622-**planet-labs-dove-satellite-photos**.html

[Editor's summary. For the full article see the link cited above]





Dove 1 and Dove 2 launched two days apart this past April, with Dove 2 hitching a ride on a Russian Soyuzt and Dove 1 on the first flight of the Orbital Sciences Corp. Antares rocket, built to deliver cargo to the International Space Station .

August 31, 2013 – The tiny satellites that could change the way humanity views and monitors its home planet are making their debut. Planet Labs has released photos of its Dove line of spacecraft, 28 of which the San Francisco firm plans to launch a few months from now to form the world's largest constellation of Earth-observing satellites, dubbed "Flock 1."

SPACE STATIONS

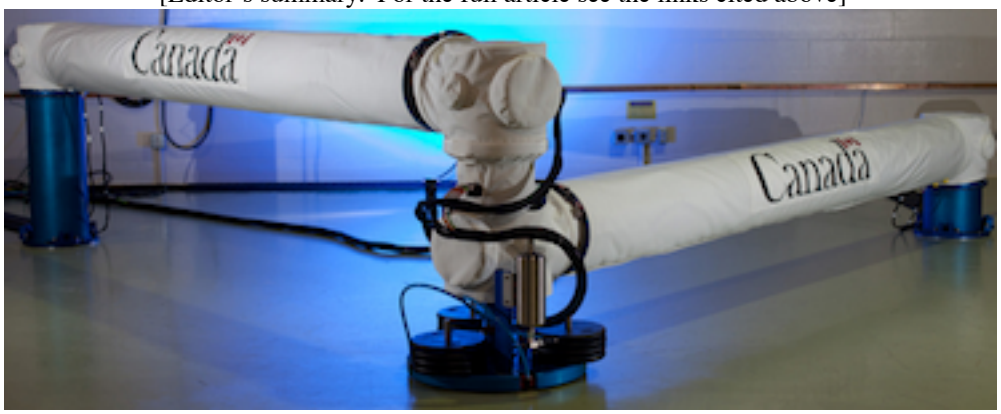
Photo Preview of Canada's Next Generation Canadarm

http://www.space.com/22122-**next-generation-canadarm-robotic-arm-photos**.html

Next Generation Large and Small Canadarms, Chris Hadfield Looks at Next-Gen Small Canadarm Prototype, Proximity Operations System Testbed, Semi-autonomous Docking System

http://www.space.com/22125-**canada-new-robotic-space-arm**.html

[Editor's summary. For the full article see the links cited above]



Next-Generation Large Canadarm is a 15-m robotic arm able to collapse and fit aboard future smaller spacecraft

Canada has developed a new version of its famed robotic space arm. In the post Space Shuttle era, new much smaller craft will be constrained to smaller and lighter payloads.

The Next-Generation Canadarm (NGC) program is designed to support both missions in low-Earth orbit and deep space, ranging from repairing communication satellites to assisting manned missions to the Moon, asteroids, Mars and other corners of the universe.

Canada's most important contributions to spaceflight over the years have been made by its robotic Canadarms. The first Canadarm, a 15 m (50-foot) arm attached to NASA's space shuttle was used to move loads from the shuttle orbiters to the space station.

After the tragic Columbia disaster in 2003 during re-entry to the atmosphere, NASA began attaching the Orbiter Boom Sensor System to Canadarm, to inspect other shuttles for any damage.

Canadarm2 arrived in 2001 to aid in the assembly of the International Space Station. The 58-foot (17.6 m) arm now takes care of much of the orbiting lab's maintenance work, supports spacewalks and captures so-called "free flyers" — spacecraft that must be grappled to the station, such as SpaceX's Dragon capsule. Canadarm2 is part of what is known as the Mobile Servicing System, comprised of the arm itself, the Mobile Remote Servicer Base System and the Special Purpose Dexterous Manipulator, also known as Dextre or the "Canada hand."

The Next Generation Program (NGC) developed for CSA by MacDonald, Dettwiler and Associates Ltd (MDA) consists of two manipulators with reaches of 15 m (50 feet), and 2.6m (8.5-foot). While the longer arm is the same length as Canadarm, it is much lighter and more compact, designed to be attached to future spacecraft, even small ones, thanks to a new telescopic boom capability with a 3:1 packing ratio: the deployed arm would be three times longer than its stowed configuration. When folded, it would take up less than 5 cubic m (177 cubic feet) of space — comparable to a minivan.

The smaller manipulator prototype is a robot "handyman" — a possible future equivalent of Dextre equipped with gear designed to help fix satellites in space and support their refueling. Many now believe that Earth-orbiting satellites can be serviced robotically. "The on-orbit servicing of the satellites is a great opportunity for the Canadian robotics technology and the Canadian industry."

http://www.space.com/22121-**next-gen-canadian-robotic-arms-to-reach-for-satellites-video**.html

Russian Spacecraft Delivers Spacesuit Repair Kit to Space Station

http://www.space.com/22145-**russian-rogress-space-station-docking**.html

[Editor's summary. For the full article see the link cited above]

July 28, 2013 The robotic Progress 52 spacecraft docked at the space station's Earth-facing port bearing food, supplies and a repair kit for a malfunctioning spacesuit. The cargo ship included nearly 2.7 tonnes (3 tons) of food, fuel, hardware and science experiment equipment for the 6-person Expedition 36 crew.

Included was a set of tools intended to help the astronauts investigate and patch up the spacesuit that malfunctioned during a July 16 spacewalk outside the station. That spacewalk was terminated early after just 92 minutes when water began to leak into the helmet of spacewalker Luca Parmitano, of the European Space Agency. Parmitano and Chris Cassidy of NASA had to abort the excursion, intended to do maintenance work to prepare the space station for the arrival of a new Russian module later this year.

http://www.space.com/12725-**russia-progress-cargo-spacecraft-infographic**.html

Japan Launches Talking 'Robot Astronaut' Kirobo Into Space

http://www.space.com/22235-**japan-launches-talking-space-robot-astronaut**.html

[Editor's summary. For the full article see the link cited above]

August 4, 2013: A small talking robot, "Kirobo," arrived at the Space Station aboard the Japanese HTV-4 (Kounotori 4) cargo ship, as part of nearly 3.5 tons of supplies and equipment to resupply the space station's six-person crew, "to keep astronauts company on the International Space Station."

Meet Kirobo: "He" is a diminutive mechanical person just 34 cm (13") tall built to converse with astronauts on long space voyages. The robot, and its ground-based counterpart **Mirata**, are part of the Kibo Robot Project to study human-robot interaction technology. Kirobo speaks Japanese and is expected to talk to JAXA astronaut Koichi Wakata when he arrives at the space station in November.

Watch: http://www.space.com/21753-**kirobo-the-robot-astronaut-is-headed-to-space-video**.html

Kibo means "hope" in Japanese and is the name of Japan's research laboratory module aboard ISS. The name of Kirobo is a merging of **Kibo** and **rob**ot. Kirobo and Mirata were built by scientists and engineers at the by the University of Tokyo's Research Center for Advanced Science and Technology.

Both robots come equipped with **voice-recognition** and **face-recognition** technology, as well as a camera, emotion recognition and natural language processing. **Follow Kirobo via Twitter - @Kibo_robo**

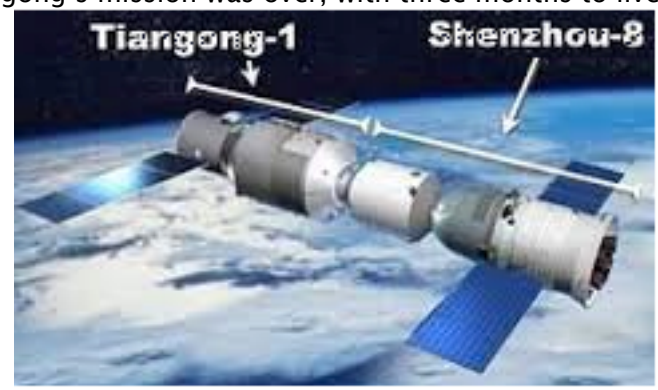
Video of Kirobo saying Hello on Space Station:
http://abcnews.go.com/Technology/kirobo-robotic-astronaut-aboard-international-space-station/story?id=20164609

China's Tiangong-1 Space Lab: Job Finished, to Deorbit Soon

Sept 19, 2013 - http://www.spacedaily.com/reports/**Last_Days_for_Tiangong**_999.html

[Editor's summary. For the full article see the link cited above]

When the crew of Shenzhou 10 departed the Tiangong 1 space laboratory in June, CSNA declared that Tiangong's mission was over, with three months to live before a fiery re-entry, date not yet certain.



It is not clear whether or not the re-entry will be controlled. The advantage of maintaining control by scheduling a rentry burn or sequence of burns would be to control where it reenters.

Tiangong 1's time in orbit has beenan exciting Chapter in China's human spaceflight program. Launched in 2011, it has been China's first space station. Three Shenzhou spacecraft docked with it. Two crews of three astronauts lived aboard the spacecraft. Tiangong 1 also hosted China's first two women in space.

"Experiments with automatic and manual dockings were performed, in addition to experiments staged inside the laboratory. Tiangong 1 was also used well as a classroom in space, as a science lesson was broadcast live to Chinese school students."

The tasks and technologies demonstrated with Tiangong 1 have laid foundations for China's goal of building a large space station in roughly a decade. ##

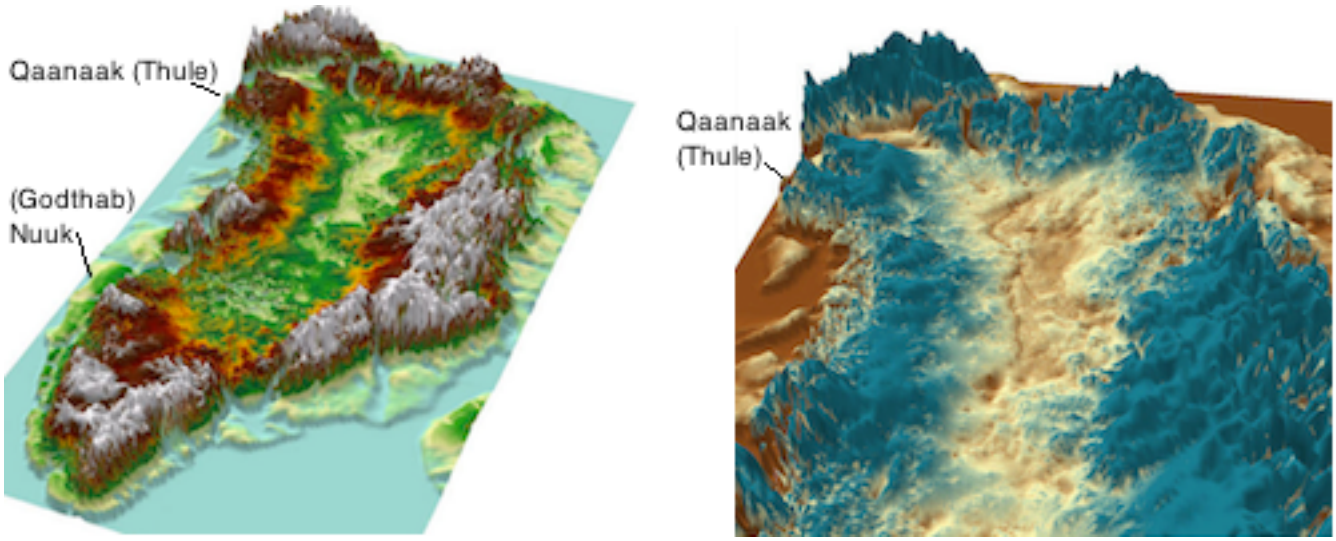
Postscript: China's planned larger space station, expected to be built in space module by module in the next decade will be open to astronauts from other nations.

http://www.spacedaily.com/reports/**Chinas_space_station_to_open_for_foreign_peers**_999.html

MISSION TO PLANET EARTH

764 km (475 mile) "Grand Canyon" Discovered by Radar under Greenland's Ice Cap

http://www.space.com/22598-greenland-s-grand-canyon-revealed-by-ice-penetrating-radar-**video**



The age of discovery isn't over yet. **A colossal canyon, the longest on Earth**, has just been found under Greenland's ice sheet. The canyon empties meltwater underneath the glacier northward into the Arctic Ocean on Greenland's north coast. The great gorge meanders northward from Summit, the highest point in central Greenland, toward Petermann Glacier on the northwest coast, covering more than 750 km (460 mi). The ravine could be even longer, but researchers don't yet have the data to prove where the canyon peters out deep under the interior ice sheet. "It may actually go farther south." ##

Opening Space for all: Small, cheap satellites may one day do our bidding

www.nbcnews.com/technology/**space-all-small-cheap-satellites-may-one-day-do-your**-6C10488674

An article by Matt Rivera and Alan Boyle [Editor's summary. For the full article see the link cited above]

Someday, swarms of satellites the size of a square tissue box will be snapping pictures, taking environmental readings and broadcasting messages from orbit. They might be launched by hobbyists and students, entrepreneurs and anyone who can afford a few hundred dollars to send something into space.

The technology for this revolution already exists: It's a type of satellite known as a CubeSat, which measures just 10 centimeters (4 inches) on a side. The term also covers satellites consisting of several such cubes all in a row and interconnected.

The CubeSat phenomenon started out as an educational experiment, but now it's turning into a crowdsourcing, crowdfunding movement. And the sky is not the limit. In 2013, more than two dozen CubeSats are due to go into orbit, **piggybacking** on commercial and government space launches.

"We had no idea CubeSats would go so far," Jordi Puig-Suari, an engineering professor at Cal Poly who is considered one of the inventors of the CubeSat concept, told NBC News in an email. "We were trying to develop a better system to educate students, and we did succeed at that. ... But we also created a whole new space ecosystem that we could not imagine at the time."

In a squat, gray building at the foot of a highway on-ramp in San Francisco, a company called **NanoSatisfi** has brought together a small team of aerospace veterans and computer engineers to build CubeSats by hand, in unpretentious surroundings.

"We take advantage of all the industries on Earth, from cellphones, smartphones, UAVs, robotics" etc., said NanoSatisfi cofoundr Peter Platzer, former research physicist and Wall Street trader. It started with a hobbyist computer called an Arduino. The engineers at NanoSatisfi decided to put those Arduinos to a more serious use: They installed them inside the standard CubeSat frame. NanoSatisfi's first two satellites, dubbed ArduSats, will hitch a ride in August on a robotic Japanese cargo ship heading for the International Space Station — where they'll be kicked out into space using a spring-loaded launcher.

From Kickstarter to space

The cost of building each ArduSat is close to $200,000 [Editor: watch for that figure to come down

substantially], and launch costs amount to another $100,000 or so. That's far less than the price tag for large-scale satellites, which can range from $100 million to more than $1 billion. To get the project launched, Platzer and his partners raised more than $100,000 through a Kickstarter campaign, and supplemented that amount with their own money and more than $1 million in venture-capital funding.

Once the ArduSats are active, NanoSatisfi's clients will be able to conduct their own experiments in space. Each satellite is equipped with 10 sensors — including a Geiger counter, a magnetometer and a camera. One of the satellites will be dedicated to schools. The other will be rented out at the rate of $250 per week, with special deals available for the Kickstarter contributors. A library of basic apps is being devloped for use on the satellites and publishing the apps online so that anyone can tweak the programming.

Station keeping: CubeSats control their orbit, not with expensive rocket thrusters instead, but with gyro-type reaction wheels and compass-type magnetic devices to keep their orientation steady. They stay in orbit for only a few months before their orbits decay and they burn up in the atmosphere. But the low cost of a CubeSat means it's relatively inexpensive to send up replacements.

NanoSatisfi plans to launch as many as 150 more satellites over the next five years. The first commercial applications will be in the education market. "Our goal is to have 500,000 students in five years having access to a satellite, and really make this a hands-on tool," Platzer said.

ArduSats could also serve as the building blocks for a low-cost weather monitoring network. Platzer believes such a network could unlock billions of dollars in economic benefits.

This is a major sea change, letting people everywhere “play” in a field up till now reserved for national space agencies, gving everyday people a personal connection to the final frontier. That's what Tim DeBenedictis, founder and owner of Southern Stars, is counting on as he launches SkyCube, a satellite system linked to a mobile app platform that will let people send images and short messages from orbit.

Getting there and deorbiting when the mission ends

SkyCube is due to be included in a cargo shipment to the space station in December. It will be shot into orbit with the same launching system used for the ArduSats. DeBenedictis has also raised more than $100,000 through Kickstarter, but also plans to cover costs through sponsorships. Once the satellite is deployed, sponsors will be able to broadcast messages and receive images from space for as little as $1 using the SkyCube mobile app. SkyCube also has a built-in answer to the problem of too much space junk. About three months after deployment, the satellite will inflate a 70-foot-wide (21-meter-wide) balloon coated with reflective titanium dioxide powder. The balloon, visible from the ground, should create enough drag to bring the satellite down for planned destruction.

Just the start - KickSat raised nearly $75,000 through a , and will get a free launch, thanks to NASA's Educational Launch of Nanosatellites program. Bob Twiggs, an engineering professor Kickstarter campaignat Morehead State University in Kentucky who worked with Puig-Suari to come up with the CubeSat concept in 1999, says he's now working on a project to launch 2-inch-wide (5-centimeter-wide) "femtosatellites" called PocketQub Those should theoretically launch for one-eighth the cost of a CubeSat. If CubeSats are the iPhones of the satellite world, PocketQubs are the iPod Nanos.

Before long, CubeSats might start going beyond Earth orbit: Scientists and engineers are working on schemes to send the nanosatellites to the Moon, even to the outer solar system. (A Kickstarter campaign for interplanetary CubeSats is in progress right now.)

"Realistically, in the next couple of years, it's going to be possible to put a sprite into orbit for less than $1,000, so that will bring it within the reach of hobbyists and high-school students for science fairs," Manchester said. "It's the sort of thing I wish I had when I was a kid."

How to pack a big solar sail in a tiny CubeSat
http://www.nbcnews.com/science/how-pack-big-solar-sail-tiny-cubesat-6C9765040

More about small satellites:

- How 'LunarCubes' could explore the moon http://www.nbcnews.com/id/48781719/ns/technology_and_science-space/t/how-tiny-lunarcubes-could-explore-moon-cheap/
- **To the Moon and Back with SkyCube** http://vimeo.com/47612071
- How to send CubeSats to Jupiter and beyond http://www.nbcnews.com/science/new-space-engine-aims-turn-cubesats-planetary-explorers-6C10566692
- Scientists design 3-D-printed CubeSat http://www.nbcnews.com/technology/scientists-design-3-d-printed-satellite-1C7265444

SpaceX Wins Contract to Launch Canadian Radar Satellites

http://www.space.com/22178-spacex-launch-contract-canadian-satellites.html

[Editor's summary. For the full article see the link cited above]

July 30, 2013 WASHINGTON — Space Exploration Technologies Corp. (SpaceX) will launch all three satellites for Canada's planned Radarsat Constellation Mission (RCM) in 2018 aboard a single Falcon 9 rocket, the Hawthorne, California rocket maker announced Tuesday (July 30).

The contract had been expected since January, when the Canadian Space Agency awarded MDA Corp. of Richmond, British Columbia, the 706 million Canadian dollar ($692 million US) prime contract to build the RCM satellites.

A "Sea Change"

Final terms of SpaceX's "launch reservation" contact, which was awarded by MDA Corp., were not disclosed, but the deal announces the entry of for profit commercial companies into a market previously dominated by national Space Agencies. SpaceX is expected to launch its first MDA-built satellite, an experimental multimission satellite dubbed Cassiope, this year.

That launch will be the first of SpaceX's Falcon 9 v1.1 upgrade, which features a new engine design and payload fairing and will be used on missions to launch commercial satellites to GEO transfer orbit. ##

Orbital Sciences Cygnus Cargo Vessel makes Maiden Flight to Space Station

September 18, 2013 - http://www.nbcnews.com/science/**cygnus-cargo-ship-flies-first-time-heading-space-station**-4B11190405

September 20, 2013 Cygnus cruising towards Space Station

http://www.space.com/22889-**private-cygnus-spacecraft-chasing-space-station**.html

http://www.astronomy.com/news/2013/09/**cygnus-arrives-at-the-international-space-station**

[Editor's summary. For the full article see the link cited above]

Launched atop an Orbital Sciences **Antares rocket** from the Mid-Atlantic Regional Spaceport's Pad 0A at NASA's Wallops Flight Facility in Virginia, the resupply ship **G. David Low** demonstrated for NASA that Orbtal's Cygnus freighters can safely deliver supplies to the space station. [The unmanned Cygnus cargo vessel, like Europe's ATV, is allowed to burn up in the atmosphere after undocking from ISS. So, as with ATVs, a brand new vessel must be manufactured for each run, each gets an honorary name. [Low was instrumental in winning the COTS demo mission and the CRS contract.]

Cygnus carries about 700 kg (1,540 lbs) of cargo on this first flight, mostly food for ISS' crew. After this demonstration proves Cygnus' capabilities, later missions will deliver science experiments and their related hardware, spare parts and other more critical supplies.

Cygnus and Antares are part of NASA's Commercial Orbital Transportation Services (COTS) effort. Upon successful completion of this mission, Orbital Sciences will conduct eight cargo flights to the space station under a $1.9 billion Commercial Resupply Services (CRS) contract with NASA.

En route to the station, there was a glitch. Rendezvous with ISS wads postponed because of a data formatting issue between t Cygnus and the station appeared. This required a software patch. The delay was further extended so as not to conflict with the arrival of s a Russian Soyuz spacecraft carrying astronauts on September 25.

Artist rendering of Cygnus cargo vessel about to be grappled by the station's Canadarm

The Cygnus now joins Space-X's Dragon in carrying cargo to the Station, which is also supplied by Russia's Progress vehicles, Europe's ATVs, and Japans HTV. After arrival at ISS, the crew will have a month to unpack the spacecraft and repack it with trash before they detach and release it from the orbiting laboratory to be destroyed during its re-entry into Earth's atmosphere, the same fate as the Russian, European, and Japanese cargo carriers. Dragon is the only reusable vessel, recovered in the ocean

The Dragon Cargo vessel will soon be joined by an astronaut carrying version, not yet certified for flight. Also in the works to carry personnel to and from the Station is **Sierra Nevada's Dream Chaser** which will be able to carry a crew of 7 to the Station and return crews back to Earth, landing like a mini-shuttle. Boeing's CST-100, Blue Origin's unnamed biconic capsule, and ATK's Liberty modules are also all being developed to ferry people into space. Some of these craft are being developed to serve commercial space stations and tourist space hotels as well.

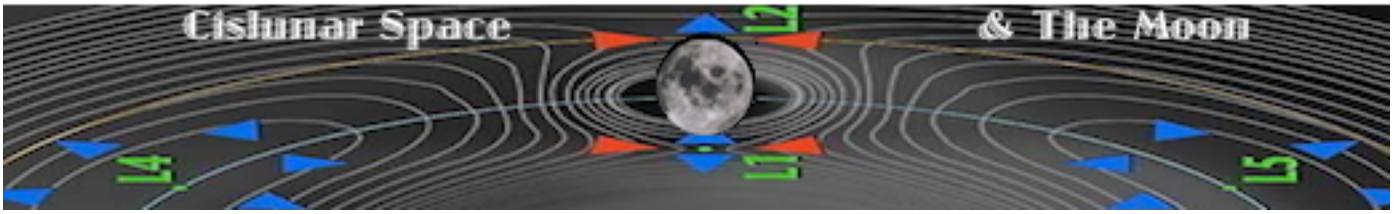
Japan launches Satellite to study Solar System Planets from Earth orbit

http://www.space.com/22806-japan-launches-epsilon-rocket.html

[Editor's summary. For the full article see the link cited above]

JAXA (**J**apan **A**erospace e**X**ploration **A**gency) launched is brand-new 3-stage Epsilon rocket designed to lower the cost of space launches by using automated systems to perform its own health checks instead of relying on human operators.

Its principal payload was the SPRINT-A (short for **S**pectroscopic **P**lanet observatory for **R**ecognition of **INT**eraction of **A**tmosphere) satellite designed to study the magnetic fields and atmospheres of solar system planets. It will observe **the atmospheres of Jupiter, Venus and Mars in ultraviolet light**. The satellite weighs 550 kg (771 lbs) and is expected to spend one year on its primary mission. ##



THE MOON

Why we insist on capitalizing "Moon" when it refers to Earth's satellite
http://www.moonsociety.org/info/capiltal-M-for-Moon.html

NASA LADEE Mission arrives in orbit about the Moon

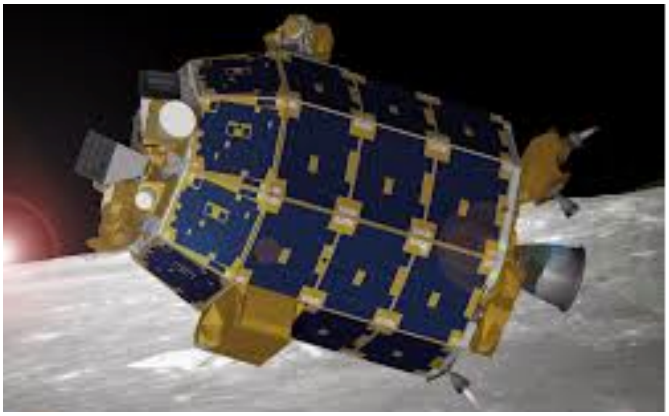
September 6-7, 2013 - **The Launch from Wallops Island** in Virginia, US
http://www.space.com/22695-**nasa-moon-mission-launches-ladee-spacecraft**.html
http://www.space.com/22700-**nasa-fixes-moon-probe-glitch**.html

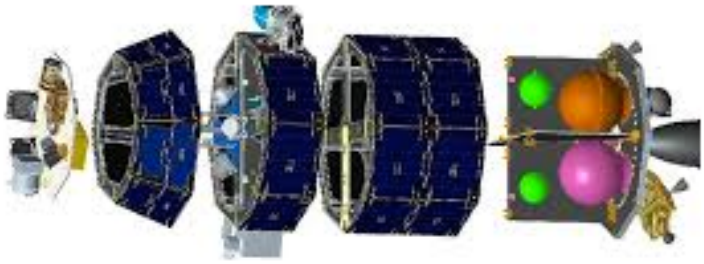
LADEE in orbit around the Moon -
http://www.universetoday.com/105254/**ladee-set-to-enter-lunar-orbit-on-oct-3-in-midst-of-government-shutdown/**

About the LADEE Mission - (Lunar Atmosphere and Dust Environment Explorer)

(LADEE is pronounced like **Lad**die, not as **Lad**y)
http://www.space.com/22609-**moons-strange-atmosphere-nasa-to-probe-video.html**
http://www.space.com/22639-**moon-dust-mystery-nasa-spacecraft**.html
http://www.nasa.gov/**mission_pages/ladee/main**/index.html
http://science1.nasa.gov/missions/**ladee**/
http://www.space.com/22692-**nasa-ladee-moon-probe-model**.html

[Editor's summary. For the full article sees the links cited above]





LADEE in orbit over the Moon - Its construction from modular components
http://www.space.com/22711-**nasa-moon-spacecraft-design-technology**.html

Background: The Surveyor 7 lander, launched in 1968, recorded a glow from the surface of the moon on the horizon before sunrise. NASA's Apollo astronauts also saw the moon glow and scientists think it could be caused by extremely small particles of dust being lofted high into the Moon's very thin atmosphere.

Will this dust cloud that seems to follow the sunrise terminator as it marches around the Moon every 29.5 days, pose problems for astronauts and settlers? Will it foul expensive sensitive instruments such as telescopes on the Moon's surface? We frankly do not know, but if it does, we will have to develop means and methods of dealing with this problem.

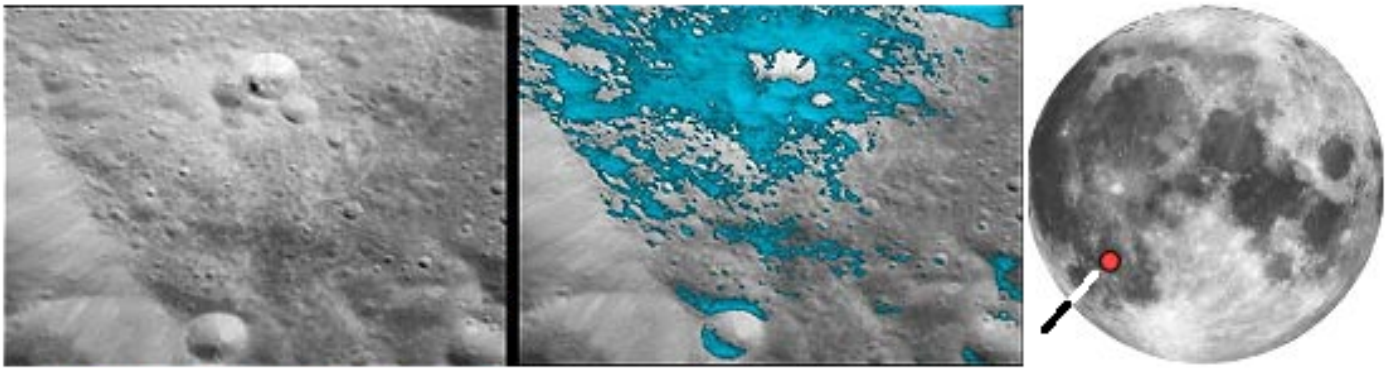
Timeline: Over the course of about a month after its September 6th launch, LADEE will circle Earth in an elliptical orbit three times before moving into lunar orbit. Once in orbit around the Moon, the spacecraft will go through a testing phase when the probe's laser communications demonstration will be tested.

After that, the LADEE spacecraft will perform 100 days of science before running out of fuel and crashing into the Moon's surface. Many people thing we have already learned all there is to know about the Moon. In fact, we keep discovering new mysteries. The Moon is much more complicated a world than we had thought. ##

Scientists Detect Water on Moon's Surface that Hints at Water Below

[Editor's summary. For the full article see this link] http://www.space-travel.com/reports/NASA_Funded_Scientists_Detect_Water_on_Moons_Surface_that_Hints_at_Water_Below_999.html

September 9, 2013 - NASA-funded research has yielded evidence of water locked in mineral grains on the surface of the Moon from an unknown source deep beneath the surface. Using data from NASA's Moon Mineralogy Mapper (M3) instrument aboard the Indian Space Research Organization's Chandrayaan-1 spacecraft, scientists remotely detected magmatic water, or water that originates from deep within the Moon's interior, on the surface of the Moon. **This is the first detection of this form of water from lunar orbit.** Earlier studies had shown the existence of magmatic water in Apollo lunar.



L: Infrared Reflectance - **M:** Blue = water absorption strength on Infrared Reflectance
R: location of the crater Bullialdus - - http://en.wikipedia.org/wiki/Bullialdus_(crater

"Detection of internal water from orbit means scientists can begin to test some of the findings from sample studies in a broader context, including in regions that are far from where the Apollo sites are clustered on the near side of the Moon. For many years, researchers believed that the rocks from the Moon were bone-dry and any water detected in the Apollo samples had to be contamination from Earth."

The findings represent the **first detection of this form of water from lunar orbit**. Earlier studies had shown the existence of magmatic water in lunar samples from the Apollo program. M3 imaged the 61 km (38 mi) wide lunar impact crater **Bullialdus**, which lies in the western part of the Mare Nubium.

"Scientists chose this area because they could better quantify the amount of water inside the rocks due to the crater's location and the type of rocks it held. The central peak is made up of a type of rock that forms deep witehin the lunar crust and mantle when magma is trapped underground. The crater is in an area with an unfavorable environment for solar wind to produce significant amounts of surface water.

This type of rock normally resides deep beneath the surface, indicating that these surface samples were excavated from the lunar depths by the impact that formed Bullialdus crater. The central portion of this crater contains a significant amount of hydroxyl - evidence that the rocks in this crater contain water that originated beneath the lunar surface.

Detection of internal water from orbit means scientists can begin to test some of the findings from sample studies in a broader context, including in regions that are far from where the Apollo sites are clustered on the near side of the Moon. For years, researchers believed that the Moon rocks were bone-dry and any water detected in the Apollo samples had to be contamination from Earth.

This discovery provides new clues about the Moon's volcanism and internal composition, and will help us understand about how the Moon formed, and how magmatic processes changed as it cooled. ##

More on this story: Sep 10, 2013 - http://www.space-travel.com/reports/Scientists_say_**water_on_moon_may_have_originated_on_Earth**_999.html

Water found in ancient Moon rocks might have actually originated on the early Earth and even survived the Moon-forming collision event. These rocks contain the mineral apatite, a calcium phosphate mineral found in Apollo samples of the ancient lunar crust brought back to Earth.

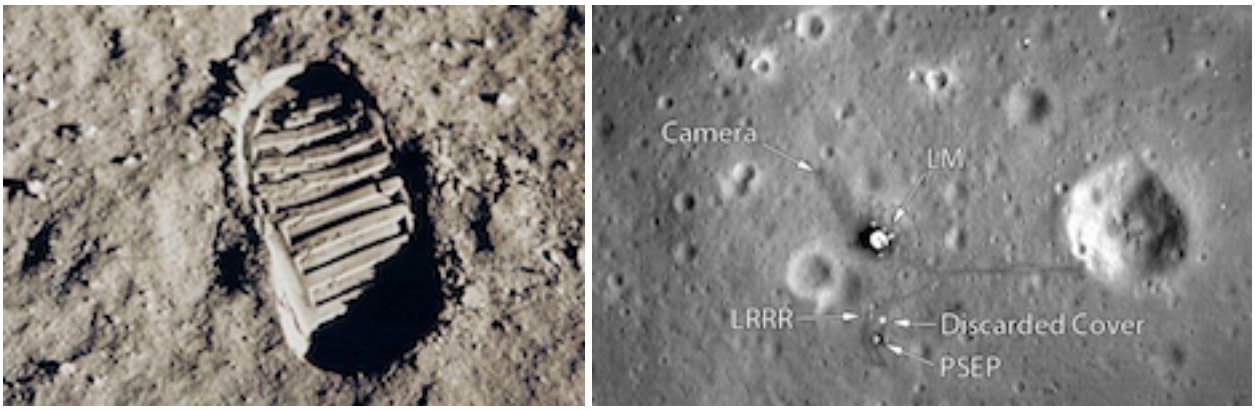
"These are some of the oldest rocks we have from the Moon, much older than the oldest rocks found on Earth. Their antiquity makes them the most appropriate samples for trying to understand the water content of the Moon soon after it formed about 4.5 billion years ago and for unraveling where in the Solar System that water came from. The water locked into the mineral apatite in the Moon rocks studied has an isotopic signature very similar to that of the Earth and some carbonaceous chondrite meteorites ... strongly suggesting a common origin." ##

Moon Bill Would Create National Parks to Protect Apollo Landing Sites

http://www.space.com/21921-**moon-bill-protects-apollo-lunar-landings**.html

[Editor's summary. For the full article see the link cited above]

A new bill introduced into the U.S. Congress would establish the Apollo Lunar Landing Sites National Historical Park on the Moon. Called the Apollo Lunar Landing Legacy Act, the bill was introduced July 8 by Rep. Donna Edwards of (D-Md.) and was co-sponsored by Rep. Eddie Bernice Johnson (D-Texas).



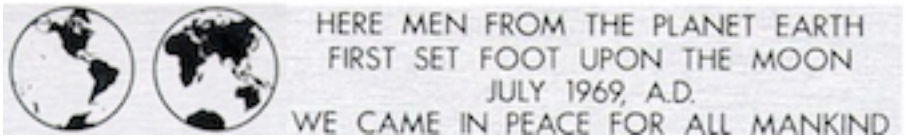
Left: the historic first bootprint on the Moon. **Right:** The Lunar Reconnaissance Orbiter Camera snapped its best look yet of the Apollo 11 landing site on the Moon, showing the remnants of Neil Armstrong and Buzz Aldrin's historic first steps on the surface around the Lunar Module.

The bill (House Resolution 2617) was referred to the Committee on Science, Space, and Technology, and in addition to the House Committee on Natural Resources.

Protect sites for posterity

The bill notes that, as commercial enterprises and foreign nations acquire the ability to land on the Moon, "it is necessary to protect the Apollo lunar landing sites for posterity." In part, the bill calls for no later than one year after the date of enactment of the act, "there shall be established as a unit of the National Parks System the Apollo Lunar Landing Sites National Historical Park."

Creating such a park will expand and enhance the protection and preservation of the Apollo lunar landing sites (http://www.space.com/20743-**space-archaeology-artifacts-preservation**.html), the bill states, "and provide for greater recognition and public understanding of this singular achievement in American history."



NOTE: The editor totally opposes this bill, not as an effort to preserve history, but as a national rather than a United Nations world effort, which latter we do support. In a brief editorial in Moon Miners' Manifesto #268, September 2013, we wrote:

"The debate in the US Congress is about whether or not this is a good or bad spending item. We favor setting aside these sites, but as World Preserves, not as American preserves. That, of course, would spark controversy as well. Someday, over the time horizon, the Lunar settlements will form an independent lunar republic. National claims are unwelcome, and have been from the gitgo. This bill, while well intentioned, infringes on that.

Yes, these sites were visited by American astronauts and, yes, the United States paid all costs. That changes nothing! The US could and should pay for site preservation expenses, but should, in the spirit of Apollo 11 set them aside for all Mankind.

The plaque left on the Moon reads: "Here men from planet Earth first set foot on the Moon July 1969. **We came in peace for all Mankind**." Note: the plaque reads "men from planet Earth," not "Men from the United States of America."

In May 2010, we called for **an "Internationally" supported Lunar Parks and Reserves Treaty**. You can read this proposal at: http://www.moonsociety.org/publications/papers/**NationalParkSystem**.pdf

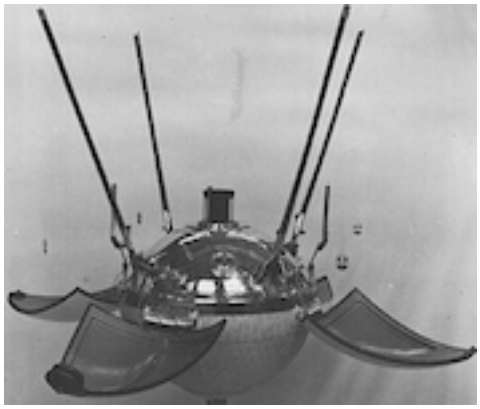
Peter Kokh

Scientist "Detectives" Search Lunar Landscape for Lost Moon Probes

June 26, 2013: A story by Leonard David relevant to the preceeding article
http://www.space.com/21723-**lost-moon-probes-hunt-lro**.html

[Editor's summary. For the full article see the link cited above]

The Moon is the final resting ground for dozens of landed and crashed spacecraft, many of which have been pinpointed recently by searching scientists.



Luna 9

Luna 13

Locating the former Soviet Union's **Luna 9** would be a major historical find. It was **the first spacecraft to achieve a lunar soft landing and to transmit photographic data to Earth.** After landing in the Ocean of Storms on February 3, 1966, the four petals, which formed the spacecraft, opened outward and stabilized the spacecraft on the lunar surface.

"We are still looking for [the Soviet Union's] Luna 9 and 13," said Jeff Plescia, a space scientist at the The Johns Hopkins University's Applied Physics Laboratory in Laurel, Md. "Those were the small beach ball' shaped spacecraft. The beach ball might be hard to find, but it made a descent on a larger vehicle which then popped the beach ball off."

Plescia had assumed that it would be possible to find the landing sites of Luna 9 and 13 by spotting **albedo marks** — a change in the lunar surface brightness made by their descent engines. He is joined in the hunt by Mark Robinson of Arizona State University, principal investigator for the Lunar Reconnaissance Orbiter Camera, or LROC. They have had no "luck" so far. Using observations by NASA's sharp-eyed Lunar Reconnaissance Orbiter for example, researchers have located and imaged Apollo Moon landing leftovers, old Soviet-era spacecraft and, more recently, the impact locales of NASA's twin Grail spacecraft that were deliberately crashed into a mountain near the Moon's north pole.

No luck so far http://www.space.com/18905-moon-spacecraft-dumping-ground-infographic.html

The search is ongoing to find the exact location of several pioneering Moon landers. Yet another search involves the impact sites of Apollo lunar module ascent stages, hardware discarded once moonwalking crews were snug within their respective command modules in orbit above the Moon.

Ascent stages were intentionally impacted into the surface as part of the Apollo Passive Seismic Experiment that studied the propagation of seismic waves through the moon to yield a detailed look at the body's internal structure. "Given that we have found the impact sites from Grail, you would think we could find those craters, but, again, no luck so far."

These, like the craters made by the third stage of NASA's Saturn Moon rocket, "are important to locate to understand how large a crater was made and to have precise coordinates so that the old Apollo era crustal velocity measurements can be reanalyzed."

Fates of failed spacecraft: Why all the focus on Moon junk?

"There may be several kinds of value here," said Philip Stooke, associate professor in the Department of Geography at the University of Western Ontario in Canada. "One is a detective story," he said, stressing that images may help resolve the fates of failed spacecraft. An example is the Soviet Union's Luna 23, which made it to the Moon and transmitted for several days in 1974 but failed to collect a sample and return it to Earth as planned.

"At the time, people said it landed hard and damaged its sample drill. Now people are suggesting it fell on its side, and the LRO images seem to support that idea," Stooke said. "Did NASA's Surveyor 4 fail before or after landing? If we could find it, we could distinguish between an intact lander and a debris field." ##

LRO Photos show Soviet Lunokhod 2 traveled 5 km further than thought

http://www.space.com/21923-**soviet-moon-rover-driving-record**.html
http://en.wikipedia.org/wiki/**Lunokhod_2**

[Editor's summary. For the full article see the link cited above]

The remote-controlled Lunokhod 2 moon rover was long thought to have traveled 23 miles (37 kilometers) on the lunar surface back in 1973. But a Russian team recently upped the estimate to 26 miles (42 kilometers), using images snapped by NASA's Lunar Reconnaissance Orbiter.

NASA Seeks Data on Commercial Robotic Lunar Lander Capabilities

http://www.space-travel.com/reports/
NASA_Seeks_Information_on_Commercial_Robotic_Lunar_Lander_Capabilities_999.html

July 2, 2013 - NASA has issued a Request for Information that will help agency officials better understand current plans in the US commercial space industry for a robotic lunar landing capability that could enable commercial and agency missions.

Hundreds of new technologies and experiments aboard the International Space Station are giving humans the tools we need to explore the unknown. New robotic commercial capabilities on the Moon could extend that research in important ways, just as NASA expertise could help advance commercial endeavors to reach the Moon."

NASA does not envision an exchange of funds between the agency and any industry partners. Potential Contributions to a partner could include

√ Technical expertise of NASA staff on integrated teams,

√ Providing NASA center test facilities at no cost, or

√ Contributing hardware or software for commercial lander development and testing.

A commercial lunar lander jointly developed with NASA would capitalize on NASA's previous investments and expertise in lander technologies. The goal is to stimulate a commercial capability to deliver payloads to the lunar surface reliably and cost-effectively. Such a capability could enable new services of interest to NASA to support technology demonstrations and science objectives, such as sample returns, resource prospecting at the lunar poles and geophysical network deployment. These services would require the ability to land small- and medium-class payloads, ranging from 30 to 450 kg (62 to 992 lbs), at various lunar sites.

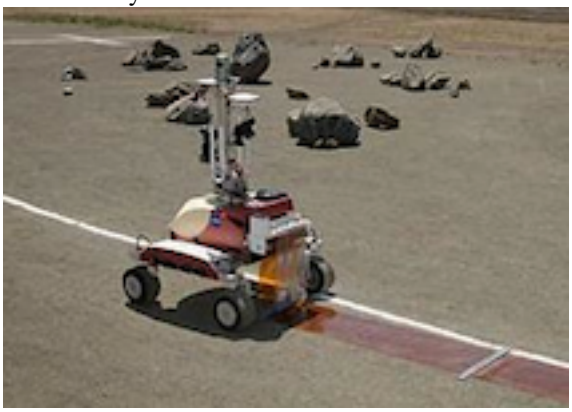
A potential partnership could support launch of a lander as early as 2018. Responses to the RFI will assess the feasibility of a commercial lunar transportation capability in the near-future.

The RFI is for planning purposes only and does not constitute a commitment by the government to contract for services.

Orbiting astronaut controls Robot on Earth, Testing feasibility of controlling robots on far side of the Moon

http://www.space-travel.com/reports/
Orbiting_astronaut_controls_robot_on_Earth_testing_feasibility_of_CU_Boulder_project_on_far_side_of_the_Moon_999.html

[Editor's summary. For the full article see the links cited above]



Boulder CO (SPX) July 04, 2013 - This K10 rover (photo above) is on NASA's Roverscape in California. The robot has just been manipulated by an astronaut in space to roll out an antenna film that CU-Boulder researchers would like to deploy on the far side of the Moon. Photo courtesy Jack Burns.

Experiments to date

An astronaut orbiting Earth in the International Space Station has remotely directed a NASA rover in California to unfurl an "antenna film" that scientists at the University of Colorado Boulder are developing for use on the unexplored far side of the Moon. When astronaut Chris Cassidy used a Space Station computer to pilot the robot across a mock lunar surface at NASA's Ames Research Center on June 17, he demonstrated for the first time that an astronaut in an orbiting spacecraft could successfully control a robot in real time on a planetary surface. The technique could have future applications for humans visiting Mars, an asteroid or the Moon.

For example, Jack Burns, director of CU-Boulder's Lunar University Network for Astrophysics Research, or LUNAR, has long advocated for placing a radio telescope on the far side of the Moon that would be able to pick up "faint whispers" from distant regions of space that would tell the tale of a time when the universe was quite young - 100 million years after the Big Bang - and the first stars and galaxies were being born.

Placing the radio telescope on the far side of the Moon is critical because it would shield the receivers from the radio cacophony emanating from Earth and it would raise the telescope above Earth's charged ionosphere, which can distort and refract incoming radio signals from space.

With the development of NASA's Orion spacecraft, it will soon be feasible to send astronauts to a location 60,000 kilometers above the far side of the Moon known as the L2 Earth-Moon Lagrange point. At that spot, the combined gravity of the Earth and the Moon would allow for the spacecraft to easily maintain a stationary “halo” orbit., above the Moon’s farside, but with Earth always above the horizon for radio relay purposes.From L, 2 Burns and his colleagues believe a rover could be sent to the Moon's surface and manipulated to roll out a "Kapton film" that would contain the radio antennas.

To test their idea, CU-Boulder researchers partnered with NASA's Human Exploration Telerobotics project, which was already working on the technology that would allow robots on a planetary surface to be controlled from orbit. NASA agreed to use Burns' vision as a test scenario. June's successful trial, during which Cassidy piloted a K10 robot for three hours in an area the size of two football fields, is the first of three planned this summer.

The K10 robot is a four-wheel-drive rover that stands about 137 cm (4.5 feet tall), weighs about 100 kg (220 lbs) and can travel about90 cm (3 ft) per second - a little slower than the average person's walking pace. For the Surface Telerobotics tests, K10 is equipped with multiple cameras and a 3D scanning laser system to perform survey work, as well as a mechanism to deploy the simulated radio antenna.

"In future missions beyond low-Earth orbit, some work will not be feasible for humans to do manually. Robots will complement human explorers, allowing astronauts to perform work via remote control from a space station, spacecraft or other habitat." Terry Fong, NASA Intelligent Robotics Group."

Burns hopes the success of NASA's Surface Telerobotics test will help bolster the far side of the Moon telescope project and generate interest in exploring a mysterious region of our nearest celestial neighbor. "The land area at the far side of the Moon is twice as large as the United States; it's a big piece of property. We haven't set foot there, either robotically or with humans, and it's just 3 days away." ##

A Telescope on top of a Lunar South Pole Mountain as early as 2016?

http://www.space-travel.com/reports/
First_ever_lunar_south_pole_mission_could_be_attempted_by_2016_999.html
http://www.cbc.ca/news/technology/story/2013/05/29/**technology-moon-express-telescope**.html

[Editor’s summary. For the full articles see the links cited above]

July 23, 2013: The **International Lunar Observatory Association** (**ILOA**) and Google Lunar X-Prize contender **Moon Express** plans to set telescopes on top of a lunar South Pole mountain as early as 2016.

The launch of Man's first-ever mission to the Moon's south pole was announced by two private US companies which plan to set telescopes on top of a lunar mountain as early as 2016. The private $100 million enterprise mission will be both scientific and commercial, the International Lunar Observatory Association (ILOA) and startup Moon Express said in a joint press release. The plan is to install a 2-meter radio antenna along with a smaller optical telescope on a 5-kilometer-high lunar peak of Malapert crater.


Left: Moon Express Lander - **Right:** Steve Durst with model of lunar telescope

This "will be the world's first instrument to conduct international astrophysical observations and communications from the lunar surface, providing scientific research, commercial broadcasting and enabling Galaxy 21st Century education and 'citizen science' on the Moon," said ILOA on their website.

The telescope's location will be able to provide the clearest images of the Milky Way galaxy because they would not be subjected to hazy interference from the Earth's atmosphere. The bulk of the Moon would also block them from radio and other electromagnetic waves created by modern human technology. The quality of the images is even expected to exceed anything produced by the best space-based instruments. Though the telescopes on the south pole would depend on costly satellite relays, the great advantage is that they would have a "direct line to Earth," said Steve Durst, founder and director of ILOA, as cited by Wired.com.

Furthermore, the location on the Malapert crater seems to be beneficial due to the milder climate in contrast with other lunar territories as the south pole gets showered with sun light for 90 per cent of the month-long lunar rotation period (and enjoys a relatively stable temperature: around -50 °C. The sunlit location would be suitable for solar panels collecting energy, averting the need for a nuclear power source.

Moon Express plans to send a small rover across the Moon to inspect the surface and what exists there, said entrepreneur Bob Richards, the company's CEO. Moon Express is hoping to accomplish its first mission in 2015 in a bid to win the $20 million Google Lunar X-Prize. Its payload will be a shoebox-sized telescope to test the ILOA's technology on the Moon.

Privately funded, the small, but very high-performance telescope known as the International Lunar Observatory precursor (ILO-X), was designed and built by Silicon Valley-based Moon Express Inc. It will allow the public to go on the Internet and view the Earth from the lunar surface on the internet.

"It's citizen science on the Moon and it's really a new model of public participation," Moon Express CEO Bob Richards told The Canadian Press on Tuesday. The flight-test hardware was officially unveiled in Vancouver by the Hawaii-based International Lunar Observatory Association. The association is led by Steve Durst, an American businessman and educator.

The telescope was tested in December 2011 from the summit of the Mauna Kea volcano in Hawaii. They pretended they were on the Moon and had scientists and individuals access it through internet software that we developed. The shoebox-sized telescope will allow people to see images they've never seen before because they will be taken from the lunar surface. People on Earth will even be able to manoeuvre the telescope by remote control, for out-of-this-world views of galaxies, stars and planets. ##

A Chinese Telescope may be on the Moon first

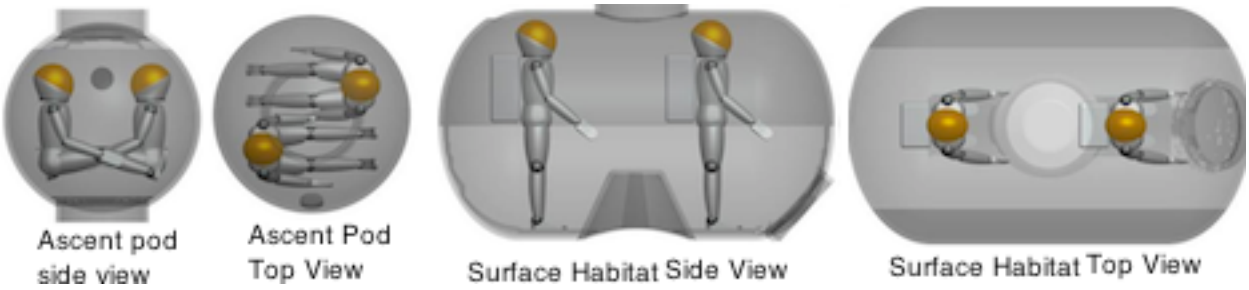
http://www.space-travel.com/reports/**Moon_landing_mission_to_use_secret_weapons**_999.html

The Chang'e-3 lunar lander, scheduled for a launch later this year, will carry a **near-ultraviolet** astronomical telescope to observe stars, the galaxy and the universe from the Moon. The telescope will observe the universe "farther and clearer" and possibly make new discoveries without disturbance from Earth's aerosphere, ionosphere and magnetosphere.

Prospects for Tourist Visits to the Moon Improve

http://www.space-travel.com/reports/
Zero_Point_Frontiers_Delivers_Favorable_Architecture_Assessment_to_Golden_Spike_Company_999.html

[Editor's summary. For the full article see the link cited above]



: http://moonandback.com/wp-content/uploads/2013/05/**Golden-Spike-Pumpkin-Illustration1**.jpg

July 29, 2013 This week Zero Point Frontiers Corp. published its report analyzing the different approaches that might be used to send people from nations around the world on commercial trips to the Moon. Working with the Golden Spike Company and its various aerospace partner companies, Zero Point Frontiers used the software it developed for NASA to help NASA Johnson Space Center design space missions.

This created the opportunity to make apples-to-apples comparisons of multiple commercial space systems. We identified several combinations of vehicles that will support Golden Spike's mission. They were all using several different types of scenarios, rocket stages, crew vehicles, and lunar landers, which made the work challenging."

The software, called the Beyond LEO (Low-Earth Orbit) Architecture Sizing Tool or BLAST, estimates the size and performance of in-space vehicles based on the number of people aboard, the destination, and the number of maneuvers each piece of the mission must perform. Using this tool, NASA engineers can design lunar, Mars, or other missions in an afternoon instead of the current 1-3 months it normally takes.

With a suite of preliminary engineering studies complete, after more detailed studies are completed later this year and next, Golden Spike plans issue a request for proposal to select launch and space vehicle providers. Revenue expeditions could be flying by the end of the decade. Golden Spike continues to gain attention regarding its $1.5-billion-dollar expeditions to the Moon. ##

'Rare Earth' Revisited: Anomalously Large Moon Key To Our Existence

http://www.forbes.com/sites/brucedorminey/2013/04/21/**rare-earth-revisited-anomalously-large-moon-remains-key-to-our-existence/**

4/21/2013 - Science fiction has continually given us the notion that once our starships start surfing the Milky Way's grand spiral arms, we'll soon find ourselves on some sort of galactic A-list. But what if intelligent species are very rare? That's the question put forth more than a decade ago in the book, "**Rare Earth: Why Complex Life is Uncommon in the Universe**," by paleontologist Peter Ward and astronomer Donald Brownlee, both at the University of Washington in Seattle.

Just this week, NASA announced that the Kepler space observatory had discovered three terrestrial-type planets in their parent stars' habitable zones — orbital regions where a rocky planet's atmospheric pressures and temperatures allow for potential liquid surface water.

Thus, **Forbes.com** decided to check in with **Ward** about the status of the authors' "Rare Earth" hypothesis. Does the Kepler news about earth-sized planets in habitable zones change anything for you? Not a thing. We know that Earth-sized planets are out there. That does not make them "Earth-like."

In "Rare Earth" Ward and Brownlee wrote that not only intelligent life, but "even the simplest of alien life is rare" in the cosmos. They believe that animals are going to be extraordinarily rare because so many planetary processes are going to be detrimental to their [evolution].

The majority of planets are going to be where metallicities are highest — close to the centers of galaxies. But in the galactic center you are also so close to other stars. There, gravity is going to pull comets out from other stellar systems. How can complex life form if you get your ocean sterilized by a comet of 20 to 30 kms in diameter every 200,000 years? The center of the galaxy is also more susceptible to greater impact rates, more supernovae, and more gamma ray-bursts. Those three are animal killers.

Are astrobiologists forced to be overly optimistic about the chances of finding life in the cosmos simply to garner funding? Funding comes from the possibility of finding life out there. NASA is funded to go to other planets to find life. They don't want to go back to the Moon, there's no life there.

But the serendipitous formation of our moon early in the history of the solar system has played a great role in stabilizing Earth's axial tilt (or obliquity) over long time periods. Such stability is believed to be at least partly responsible for stable climates and the evolution of complex life here. Thus, is the Moon and its effect on Earth's obliquity astrobiology's 800-pound gorilla?

Complex life goes all the way down to a flatworm. I don't think that changing obliquity is going to affect that so much, but if we think of complex life as an ecosystem, could you get a rain forest or a coral reef without the influence of our Moon? If the Moon doesn't make us rare, then I don't know what does. Its formation was a tricky, pretty low-probability event.

Editor's comment: The sort of major planetary collisions that seem to have created the Earth-Moon system may not be that rare. Is not Uranus' sideways axial tilt another example, right in our own system? And what do we mean by rare? One in ten? One in a hundred? One in a thousand?

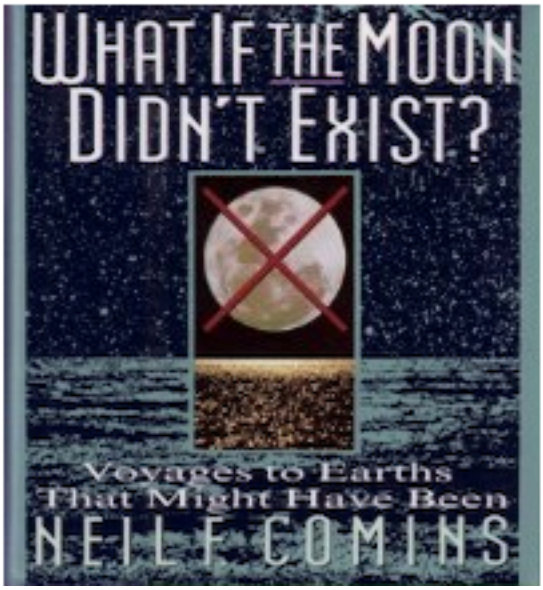
Our solar system is not "near" the center of our galaxy, so that argument is spurious. Maybe the "majority of planets are near the center, and maybe they are desolate. So? There are going to be solar systems everywhere.

Rarity is relative. If there were only one life bearing planet per galaxy, there would still be hundreds of billions of life-bearing worlds in the Universe. The Universe is that big! And who says there are not uncounted numbers of universes, each in its own space and time. Not to forget that anything that can happen once, can happen again and again. And life, once begun, is very very very versatile and adaptive.

More, given that communication seems to be constrained by the speed of light so that inter-world conversations and influence of any kind may be extremely rare, that does not change the feeling of fellowship we ought to feel with **whomever** is out there, **wherever**, **whenever**. We share the same creatural condition. And that is wonderful and wondrous, whether there is ever confirming contact or not.

PK

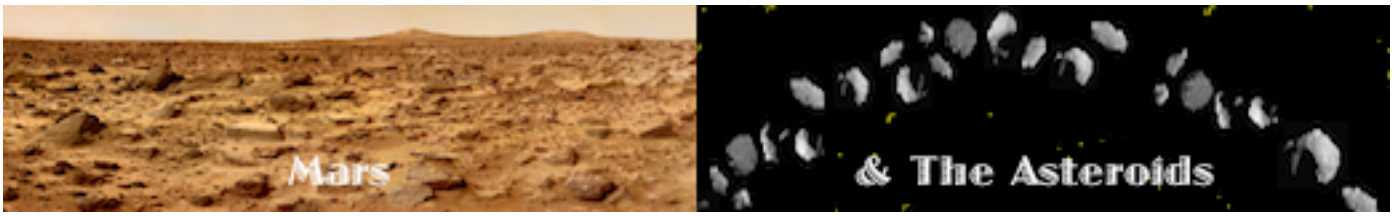
We Recommend this Book by Neil F. Comins:



What If the Moon Didn't Exist?
Voyages to Earths
That Might Have Been

Publication Date: **November 1993** | ISBN-10: **0060168641** | ISBN-13: **978-0060168643**
A look at how life on Earth could be different if the Moon did not exist analyzes how the location of the Moon in relation to Earth affects human, animal, and plant life.

Comins has also published "**What If the Earth Had Two Moons?: And Nine Other Thought-Provoking Speculations on the Solar System**"
Also available on Amazon.com

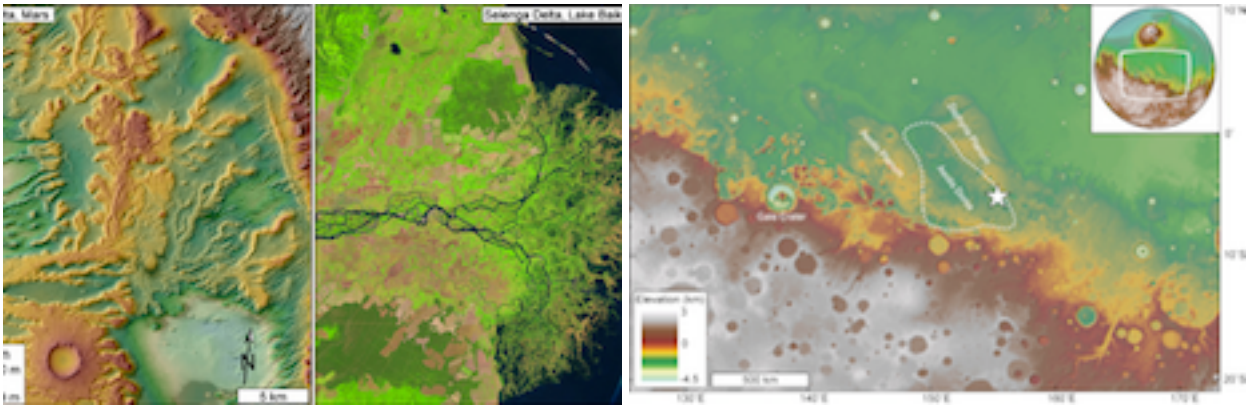


MARS

Ancient Mars River May Have Flowed into Huge Ocean

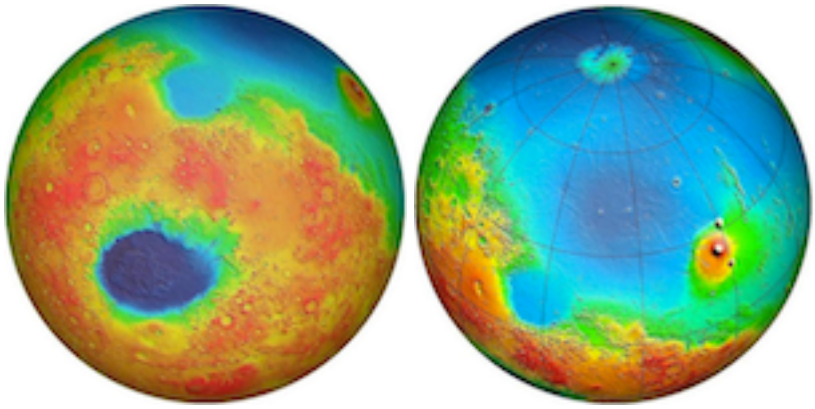
http://www.space.com/21984-**mars-ocean-ancient-river-delta**.html

[Editor's summary. For the full article see the link cited above]



Left: A shaded relief map shows channelized sedimentary deposits interpreted as an ancient river delta in Aeolis Dorsa, Mars. **Middle:** A modern delta on Earth. **Right:** Overview map showing the location of an ancient river delta (star) within Mars' Aeolis Dorsa region, which is found along the boundary between Mars' cratered southern highlands and smooth northern lowlands

July 17 – Scientists have spotted more evidence that an enormous ocean on Mars covered much of the planet's surface billions of years ago. The latest clues were found in photos from the Mars Reconnaissance Orbiter whose images show what appears to be an ancient river delta, which may have emptied into a vast ocean that inundated up to one-third of the Red Planet long ago, a new study reports.



Editor: The blue area in the Northern Hemisphere, known as Vastitas Borealis (Northern Vastness) is a gigantic basin which once could have held an ocean. **Comment:** a sceptic once told me that he thought this basin was made by a giant impact (obviously?) and not an by an ocean. Our reply is that oceans do not form basins, they form "in" basins already there. Whether plate tectonics had a role in shaping Mars is another question The three giant Tharsis Ridge Volcanoes, in a neat row, indicate that there was some plate movement over a hot spot. But it looks like that process came to a halt long ago. Water in the crust and magma lubricated sliding plates. There must not have been enough subsurface water to keep plate tectonics going very long.

"Scientists have long hypothesized that the northern lowlands of Mars are a dried-up ocean bottom, but no one yet has found the smoking gun," study co-author Mike Lamb, an assistant professor of geology at the California Institute of Technology (Caltech) in Pasadena, said in a statement.

The new study, further bolsters the hypothesis, using images of a slice of the northern lowlands from the HiRise camera on the Mars Reconnaissance Orbiter which can distinguish features as small as 25 cm (10 in) on the surface. They found that the inverted channels spread out markedly and slope steeply downward near their end, just as streams here on Earth do when they approach and empty into the sea.

Ancient river deltas have been discovered on Mars before. But most of them have been spotted inside craters or other geologically bounded regions, providing evidence for lakes but not global oceans. The newfound delta, in an unconfined region, is different — and points to the existence of a large body of water in the northern hemisphere of Mars. Just how big this sea or ocean was remains an open question. It might even be the long-hypothesized global ocean, which some scientists suspect covered a third of Mars.

Editor: one might think that MRO's high resolution cameras, could find ancient shorelines, if they existed, or even parts of shorelines. But winds could have eroded them to the point where they blend in to the surface too well to get attention. And if the ocean disappeared steadily but slowly, pronounced shorelines might never have formed. PK

Mars Water-Ice Clouds Are Key to Odd Thermal Rhythm

www.marsdaily.com/reports/**Mars_Water_Ice_Clouds_Are_Key_to_Odd_Thermal_Rhythm**_999.html

[Editor's summary. For the full article see the link cited above]

NASA JPL Pasadena CA Jun 14, 2013

Researchers using NASA's Mars Reconnaissance Orbiter were surprised to find that temperatures in the Martian atmosphere regularly rise and fall, not just once each day, but twice, with a temperature maximum in the middle of the day, and again a little after midnight. Temperatures swing by as much as 32 ° kelvins (58 °F) as detected by the orbiter's Mars Climate Sounder instrument.

Atmospheric Tides

These Mars Climate Sounder observations sampled a range of times of day and night all over Mars. The pattern is dominant globally and year-round. Global oscillations of wind, temperature and pressure repeating each day or fraction of a day are called atmospheric tides. In contrast to ocean tides, they are driven by variation in heating between day and night.

Earth's atmospheric tides produce little temperature difference in the lower atmosphere away from the ground. On Mars, with only about one percent as much atmosphere as Earth, they dominate short-term temperature variations throughout the atmosphere.

Once a day tides are called "diurnal." The twice-a-day ones are called "semi-diurnal." The semi-diurnal pattern on Mars was first seen in the 1970s, but until now it had been thought to appear just in dusty seasons, related to sunlight warming dust in the atmosphere.

The explanation seems to lie in Mars' water-ice clouds that are present most of the Martian year. The light relatively transparent clouds (similar to Earth's cirrus clouds) in the equatorial region between about 10-30 km (6-9 mi) above the surface of Mars absorb infrared light emitted from the surface during daytime..

The absorption by these thin clouds is enough to heat Mars' middle atmosphere each day. The unexpected semi-diurnal temperature pattern, with its maximum temperature swings occurring away from the tropics, has now been replicated in Mars climate models by including the radiative effects of the water-ice clouds.

Mars is a cold and dry world with little water. That said, there is actually more water vapor in the Martian atmosphere than in the upper layers of Earth's atmosphere. ##

ExoMars 2016 Set To Complete Construction

http://www.marsdaily.com/reports/**ExoMars_2016_Set_To_Complete_Construction**_999.html

http://en.wikipedia.org/wiki/ExoMars

[Editor's summary. For the full article see the links cited above]

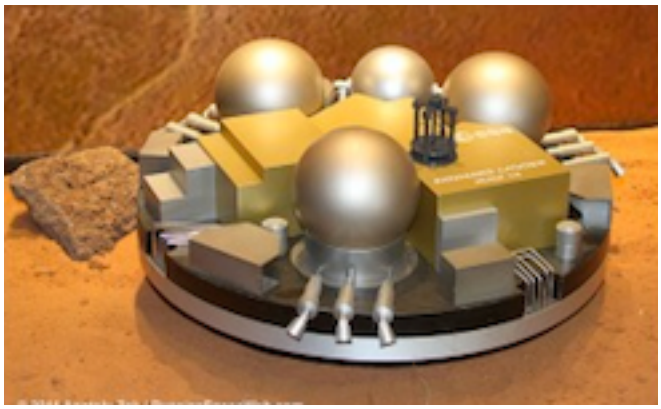
ESA's mission to Mars in 2016 is now in the final stage of construction by Thales Alenia Space.

ExoMars will fly two missions, in 2016 and 2018, in a partnership between the European and Russian space agencies, ESA and Roscosmos. ExoMars' main goal is to answer one of the outstanding scientific questions of our time: has life ever existed on Mars?

As a benefit, ExoMars will develop new European technical capabilities in landing, roving, drilling and preparing samples to pave the way for a future Mars sample-return mission in the 2020s.

The 2016 mission will be launched in January 2016, arriving at Mars nine months later. It includes an orbiter and a lander probe:

- The **Trace Gas Orbiter** (TGO) will search for evidence of methane and other atmospheric gases that could be signs of active biological or geological processes.
- The **Entry, Descent and Landing Demonstrator Module** (EDM) will demonstrate key technologies needed for the 2018 mission and future landing missions, will also include the

2016 ESA-Roscosmos Mission: Left: Orbiter, Right: Lander

The 2018 mission is scheduled for launch in May 2018, arriving at the planet in early 2019. It will land a rover on Mars - the first with the capability of drilling to depths of 2 m to collect samples that have been shielded from the harsh conditions on the surface, where radiation and oxidants can destroy organic materials. In addition, the 2018 mission carries a Surface Platform with scientific instruments to investigate the martian environment. ##

Astrobiologists Find Clues to Early Life on Mars in Mars Meteorite

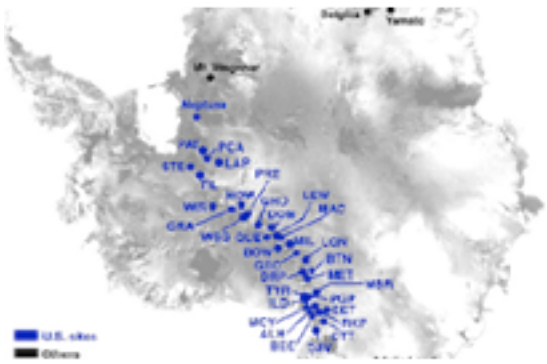
http://www.marsdaily.com/reports/
UH_Astrobiologists_Find_Martian_Clay_Contains_Chemical_Implicated_in_the_Origin_of_Life_999.html

[Editor's summary. For the full articles see the links cited]

University of Hawaii at Manoa Jun 13, 2013 - Researchers from the University of Hawaii at Manoa NASA Astrobiology Institute (UHNAI) have discovered high concentrations of boron in a Martian meteorite. When present in its oxidized form (borate), boron may have played a key role in the formation of RNA, one of the building blocks for life.

The Antarctic Search for Meteorites team found the Martian meteorite used in this study in Antarctica during its 2009-2010 field season. The minerals it contains, as well as its chemical composition, clearly show that it is of Martian origin.

One of several meteorites found on the Antarctic ice whose mineralogy betrays an origin on Mars.



Antarctic Search for Meteorites Program map of Antarctica shows the major search area for meteorites where ice moving toward mountains moves meteorites to the surface, where they can be easily seen. Credit: ANSMET/NSF

[http://www.amnh.org/education/resources/rfl/web/essaybooks/cosmic/cs_microbes.html]

Veins of Martian Clay

Using the ion microprobe in the W. M. Keck Cosmochemistry Laboratory at UH, the team was able to analyze veins of Martian clay in the meteorite. After ruling out contamination from Earth, they determined boron abundances in these clays are over ten times higher than in any previously measured meteorite.

"Borates ... can stabilize ribose, a crucial component of RNA. RNA is thought to have been the informational precursor to DNA" which may have been the first molecule to store information and pass it on to the next generation, a mechanism crucial for evolution. Although life has now evolved a sophisticated mechanism to synthesize RNA, the first RNA molecules must have been made without such help.

On early Earth, borate-enriched salt, sediment and clay deposits are relatively common, but until now, such deposits had not been found on an extraterrestrial body. This new research suggests that when life was getting started on Earth, borate could also have been concentrated in deposits on Mars. The Martian clay studied is thought to be up to 700 million years old.

"Earth and Mars used to have much more in common than they do today. Over time, Mars has lost a lot of its atmosphere and surface water, but ancient meteorites preserve delicate clays from wetter periods in Mars' history.

This find has implications for Earth

The presence of ancient borate-enriched clays on Mars implies that these clays may also have been present on the early Earth., providing chemical havens in which one of life's key molecular building blocks could form. ##

Phosphate, Required for Life, More Plentiful on Ancient Mars Than on Earth

September 1, 2013 - http://www.space.com/22618-mars-life-ingredient-plentiful.html

[Editor's summary. For the full article see the link cited above]

Phosphates, a key chemical ingredient for life, may have been more abundant on early Mars than on early Earth. Phosphate serves as the backbone of DNA and is also an essential part of the molecules cells use for energy and membranes. It was likely critical to reactions that led to the origin of life on Earth.

Mars appears to be 5-10 times richer in phosphate than Earth, based on analysis of meteorites from Mars found on the Antarctic ice, as well as scans of Mars surface by the Spirit and Opportunity rovers.

However, just because phosphate is present does not mean it is necessarily available for use in chemical reactions for life. The minerals that hold phosphate on Earth dissolve very slowly, limiting its availability in watery environments, which may have posed a roadblock to the emergence of life on Earth.

Geochemist Christopher Adcock at the University of Nevada, Las Vegas, and his colleagues examined how the phosphate-loaded minerals thought to be most common on Mars dissolved across a range of acidity levels. They found the dominant phosphate-loaded minerals on Mars are distinctly more soluble, and thus release more phosphate into water, than those most common on Earth. ##

We may all be Martians - "Life likely came to Earth on a Martian Meteorite"

http://www.marsdaily.com/reports/**We_may_all_be_Martians**_999.html

Florence, Italy (SPX) Sep 03, 2013: New evidence has emerged which supports the long-debated theory that life on Earth may have started on Mars.

Professor Steven Benner believes that an oxidized mineral form of the element molybdenum, which may have been crucial to the origin of life, could only have been available on the surface of Mars and not on Earth. "In addition", said Professor Benner "recent studies show that these conditions, suitable for the origin of life, may still exist on Mars." Brenner is with The Westheimer Institute for Science and Technology in Gainesville, Florida, US.

> "It's only when molybdenum becomes highly oxidized that it is able to influence how early life formed. This form of molybdenum couldn't have been available on Earth at the time life first began, because three billion years ago the surface of the Earth had very little oxygen, but Mars did."

The research Professor Benner presented at the Goldschmidt conference tackles two of the paradoxes which make it difficult for scientists to understand how life could have started on Earth.

- The 'tar paradox'. All living things are made of organic matter, but if you add energy such as heat or light to organic molecules and leave them to themselves, they don't create life. Instead, they turn into something more like tar, oil or asphalt. "Certain elements seem able to control the propensity of organic materials to turn into tar, particularly boron and molybdenum, so we believe that minerals containing both were fundamental to life first starting," says Professor Benner. "Analysis of a Martian meteorite recently showed that there was boron on Mars; we now believe that the oxidized form of molybdenum was there too."
- The second paradox is that life would have struggled to start on the early Earth because it was likely to have been totally covered by water. Not only would this have prevented sufficient concentrations of boron forming – it's currently only found in very dry places like Death Valley – but water is corrosive to RNA, which scientists believe was the first genetic molecule to appear. Although there was water on Mars, it covered much smaller areas than on early Earth.


Left: Earth and Mars today – **Right**: Early Mars? Someday we may "know"

"The evidence seems to be building that we are actually all Martians; that life started on Mars and came to Earth on a rock. It's lucky that we ended up here nevertheless, as certainly Earth has been the better of the two planets for sustaining life. If our hypothetical Martian ancestors had remained on Mars, there might not have been a story to tell." ##

Editor: The hypothesis that life started on Mars then hitched a ride here on a meteorite is not new. If it is confirmed someday beyond doubt, it will certainly start people thinking of themselves as Solarians, people of our Solar System, and that the whole System is ours to occupy over time. And the drive to send people to Mars to explore and possibly to settle, will become a "**Back to Mars" movement.**

For most people, Earth is all there is. "Earth is the World." At one time Africa was the world. The realization that we are Solarians and that it is our calling to spread our presence throughout the Solar System could be a powerful philosophical force in coming decades. PK

Read "**As the World Expands: The Epic of Human Expansion Continues**"

in the ARTICLES and ESSAYS section below.

Additional Reading Selections:

http://www.weather.com/**video/did-earth-life-come-from-mars**-38610
http://news.discovery.com/space/alien-life-exoplanets/**mars-life**-120315.htm
http://www.space.com/22003-**alien-life-detector-mars-technology**.html
http://arachnoid.com/lutusp/mars.html
http://discovermagazine.com/**2001**/aug/featmars
http://theconversation.com/just-out-of-curiosity-did-life-on-earth-come-from-mars-11109

Editor's comment:

Yes, but .... if we don't find surviving traces on Mars of primitive early life forms or their fossilized leavings after thorough robotic, then human probing, then we'll have to figure out how life could have started on Earth "anyway," despite the early hostile conditions being cited.

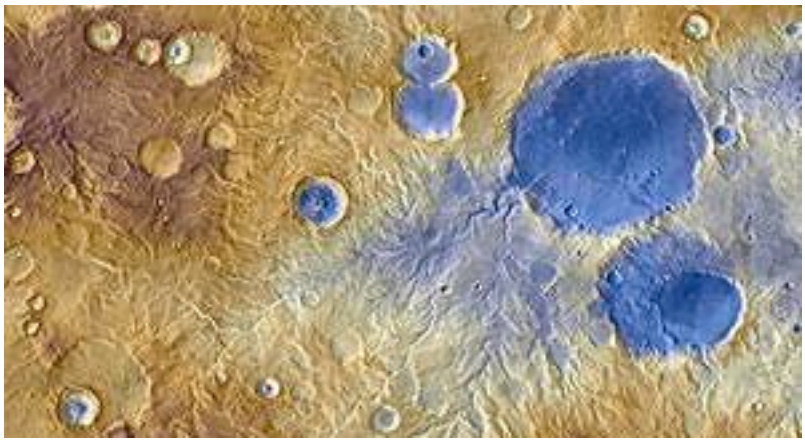
It is an exciting time to be alive. ##

Could snowfalls have carved Martian Valleys?

http://www.marsdaily.com/reports/**Ancient_snowfall_likely_carved_Martian_valleys_999.html**

[Editor's summary. For the full article see the link cited above]

July 24, 2013 - Valley networks branching across the Martian surface are a strong indiction that water once flowed on Mars. But where did that water came from? Did it bubble up from underground or did it fell as rain or snow? A new study by Brown University researchers indicated precipitation: rain or snow.



According to the study, water-carved valleys at four different locations on Mars appear to have been caused by runoff from snow or rain that falls when moist prevailing winds are pushed upward by mountain ridges. These findings could shed new light on the planet's early climate and atmosphere.

Kat Scanlon, a geological sciences graduate student at Brown who led the research, is well-acquainted with the orographic effect, from her graduate work in Hawaii, where moist tropical winds from the east are pushed upward when they hit the mountains of Hawaii island. Lacking the kinetic energy to reach the mountain summit, winds dump their moisture on the eastern side of the island, making parts a tropical jungle. The western side, in contrast, is nearly a desert because it sits in a mountain rain shadow.

Scanlon thought similar orographic patterns might have been at play on early Mars and that the valley networks might be an indicator. Researchers identified four locations where valley networks were found along tall mountain ridges or raised crater rims. To establish the direction of the prevailing winds at each location, the researchers used a newly developed general circulation model (GCM) for Mars.

"The model simulates air movement based on the likely gas composition of the early Mars atmosphere. A model of orographic precipitation suggested where precipitation would be likely to fall in each of the study areas - it would have been heaviest at the heads of the densest valley networks. "Their drainage density varies in the way you would expect from the complex response of precipitation to topography," Scanlon said. "We were able to confirm that in a pretty solid way."

A new comprehensive general circulation model predicts Mars had a cold climate, so precipitation modeled in this study was snow. But this snow could have been melted by episodic warming conditions to form the valley networks, and indeed some precipitation could have been rain during this period. How fast can you melt a giant snowbank? Need rain? Is it even possible to get enough discharge to carve the valleys with just the snowmelt?" The answers could provide insight into the climate on Mars billions of years ago.#

How Mars' atmosphere got so thin: New insights from Curiosity

www.marsdaily.com/reports/**How_Mars_atmosphere_got_so_thin_New_insights_from_Curiosity_999.html**

[Editor's summary. For the full article see the link cited above]

July 19, 2013 - New findings from the Curiosity rover give clues to how Mars lost its original atmosphere, which may have been much thicker than today's. "These are the first really high-precision measurements of the composition of Mars' atmosphere," said Sushil Atreya, professor of atmospheric, oceanic and space sciences at the University of Michigan, and co-author of two related papers published in the July 19 issue of Science, and co-investigator on Curiosity's Sample Analysis at Mars (SAM) suite of instruments.

SAM measured the abundances of different gases and isotopes of carbon and oxygen in samples of Martian air. This showed that heavy isotopes of carbon and oxygen were more abundant in today's thin atmosphere compared with the proportions in the raw material that formed the planet (deduced from proportions in the sun and other parts of the solar system.) This provides evidence for the loss of much of Mars' early atmosphere, how it occurred: Mars' atmosphere escaped from the top: clear evidence of a substantially more massive atmosphere, hence a warmer, wetter Mars in the past.##

International Space Agencies Outline Steps to Take Humans to Mars

marsdaily.com/reports/International_Space_Agencies_Outline_Steps_to_Take_Humans_to_Mars_999.html

[Editor's summary. For the full article see the link cited above]

Proposal would use the International Space Station (ISS) as a stepping stone

Washington (RIA Novosti) Aug 22, 2013

At a news conference, NASA Administratro Charles Bolden, stated that a consortium of 12 space agencies - **NASA**, **Roscosmos**, and the space agencies of **Canada**, **France**, **Germany**, **India, Italy**, **Japan**, **South Korea**, the **United Kingdom**, **Ukraine** and the **European Space Agency** on Tuesday released a blueprint for future space exploration that would use ISS, the International Space Station, as a stepping stone for human missions deeper into space, including to Mars.

The "**Global Exploration Roadmap**", published on NASA's website, starts with a conceptual mission scenario of missions in the lunar vicinity, including an asteroid mission, as prepartation for international manned missions to Mars in the 2030 timeframe.

The International Space Exploration Coordination Group (ISECG) put together the roadmap that "reflects a common long-range human exploration strategy that begins with the ISS and expands human presence into the solar system, leading to human missions on the surface of Mars."

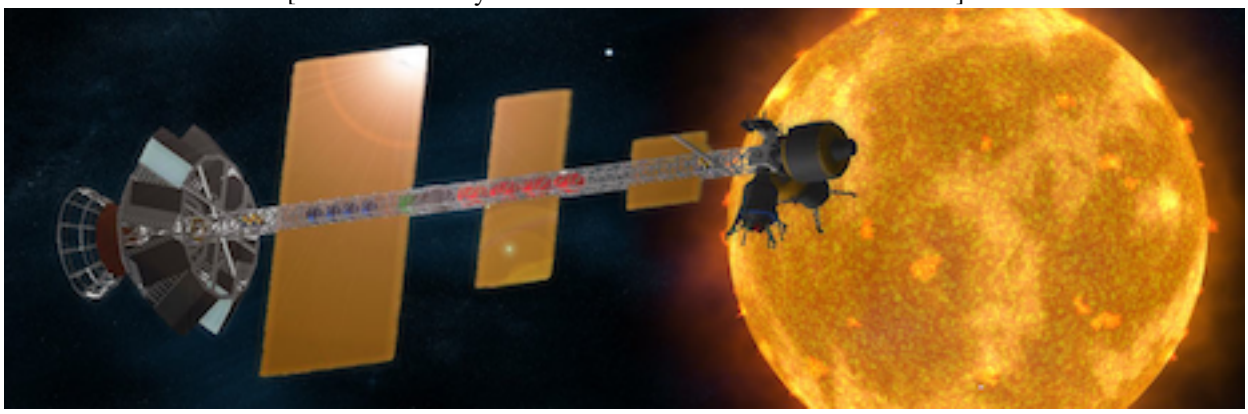
The report calls for the ISS to be used as "the foundation of exploration" and for international cooperation to be the hallmark of missions as humans push deeper into space, with longer astronaut stays in space, presenting new risks.

The report also proposed new missions to the Moon and came out in favor of a project proposed by President Barack Obama in April, to capture and redirect an asteroid. The rationale is that extended duration missions to the Moon and "missions to an easily accessible asteroid will enable discoveries and allow demonstration of the transportation, habitation, robotic servicing and other key systems on which long-duration missions into deep space must rely." The US Congress is not yet aboard, however.

UA-Huntsville working on pulsed nuclear fusion system for distant missions

http://www.uah.edu/news/research/2501-**slapshot-to-deep-space**#.UfQfiRa0Lww

[Editor's summary. For the full article see the link cited above]



HUNTSVILLE, Ala. — A series of nuclear "slapshots" using magnetic pulses to slam nuclei into each other inside hockey pucks made of a special, lightweight salt, may be the ticket to Mars, if we want to get there faster than conventional rockets will allow, to reduce radiation exposure.

A physics team from The University of Alabama in Huntsville's Department of Mechanical and Aerospace Engineering soon will take delivery of a specialized system to see if they can "Z-pinch" a tiny bit of that salt into the heart of a star. The goal is to develop a small, lightweight pulsed nuclear fusion system for deep space missions, on e that would cut travel time down tosix to eight weeks instead of six to eight months.

In hockey, a "Slapshot" is a hockey term for digging the head of the hockey stick into the ice to bend the shaft, like an archer's bow, storing energy for a sharper snap against the puck and drive it down the ice rink. The UAH team will attempt to drive a hollowed-out puck in on itself, fusing lithium and hydrogen atoms and turning a little of their mass into pure energy.

The “pucks” are approximately 5 cm (2”) inches wide and 2.5 cm (1”) thick, smaller than a regulation 7.62 cm (3”) puck, and are made of lithium deuteride (LH_2), the lightest metal combined with the middle-weight form of the lightest element.

At the heart of the Sun, nuclear fusion combines four hydrogen atoms to make one atom of helium, with a small amount of matter converting into pure energy. The UAHuntsville experiments will start at the midpoint of that cycle, where heavy hydrogen (one proton and one neutron) fuse with each other or with lithium (not a normal part of solar fusion). That will be quite a trick to pull off. “Getting nuclei together is like firing two positively charged BBs up the slopes of Mount Everest to meet head-on at the peak.”

The team (UAHuntsville, Boeing, NASA’s Marshall Space Flight Center, and a growing list of other participants) will experiment with the Decade Module Two, or DM2, an L3 Communications pulsed power design used by the Department of Defense for weapons effects testing in the 1990s in Tullahoma, TN, relocated to the Aerophysics Lab on Redstone Arsenal this summer.

“DM2 comprises banks of capacitors that store an electrical charge for release on command. This strips the target into an electrified gas or plasma. Electricity flowing through it generates a magnetic field that compresses the plasma. That's the Z-pinch effect. It's equivalent to 20 percent of the world's power output in a tiny bolt of lightning no bigger than your finger, a tremendous amount of energy in a tiny period of time, just a hundred billionths of a second" - about the same energy as a liter of gasoline.

The plasma reactions and their by-products will tell whether the theory behind the pulse fusion propulsion model is valid. Will the electrons stripped off the atoms will carry away a lot of heat? "Once we have a good understanding, we can extrapolate this to see what we have to do to exceed break-even for propulsion applications."

If the studies work out, they could lead to a system that fuses lithium-deuterium pellets and uses an electromagnetic field as the nozzle for that the exhaust pushes against and also captures part of the energy to recharge the system. That is the next area to tackle if the Z-pinch approach proves out.

The pulsed fusion engine — like any other rocket engine — is a flying tea kettle. Cold material goes, gets energized and hot gas pushes out. ‘In a working nuclear pulse engine, pellets would be fired up to 10 times a second and produce up to 10,000 Newtons of thrust. That’s a modest 2 percent of what a Space Shuttle Main Engine could do. With a spaceship weighing hundreds of tons, the crew likely would feel nothing more than a light tapping.’“So you’re not flying pinned to the back of the cabin,” Cassibry added.

Unlike the Shuttle, the pulsed fusion engine is not designed for launch from Earth nor will it run out of fuel in 8-1/2 minutes. Instead, it will run continuously for weeks at a time to quickly spiral out of Earth orbit and then set course for another planet. After a high-speed coast lasting a few weeks, the engine would fire for another week or two to decelerate into orbit around the destination planet. Alternatively, it could be attached to an asteroid and run for months to gently nudge its trajectory away from Earth.

Related Article - http://www.spacedaily.com/reports/prnewswire-space-news.html?doc=201307250719PR_NEWS_USPR____MN52742&showRelease=1&dir=0&categories=AEROSPACE-AND-SPACE-EXPLORATION&andorquestion=OR&&passDir=0,1,2,3,4,5,6,15,17,34

Autonomous Rover Drills deep in the Atacama, testing for Mars

http://www.spacedaily.com/reports/**Autonomous_Rover_Drills_Underground_in_the_Atacama**_999.html

[Editor’s summary. For the full article see the link cited above]

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July 09, 2013 A rover named Zoe recently traveled the Atacama Desert in Chile, the driest place on Earth with a landscape that has much in common with Mars harsh terrain: unrelenting UV radiation, thin cold air at high altitudes, and desiccated sand and lava flows: not especially "life-friendly," but a great place to test instruments f or future Mars missions.

For two weeks plus, Zoe using its drill, cameras, spectrometers and other sensors, analyzed soil samples from above and below the surface. Mars surface is considered uninhabitable because of the harsh UV, thin atmosphere, extreme cold and acidic soil. So many believe the best place to find evidence of past or present life on Mars may be deep underground.

This trial with Zoe ended June 29, but is part of a longer 3-year project, supported through NASA's ASTEP program to advance the technology and techniques used in planetary exploration. Given Zoe's onboard autonomy software, the science team in the United States could explore the Atacama remotely, just as NASA mission control would operate a rover on Mars. However, unlike the real thing on Mars, the engineering team was on hand just i case anything went wrong.

A couple people collected ground truth, digging pits to make sure what the rover was sampling autonomously was the same as what They would get on their own. Zoe's meter-long drill would dig up a sample, then the rover deposited them into sample cups and analyzed them with instruments such as a laser Raman spectrometer (the MMRS or Mars Microbeam Raman Spectrometer). The MMRS shines a laser on the sample and measures the energy of the photons scattered back, providing a clear spectrum of each mineral phase and organic molecule.

The Raman spectrometer instrument proved remarkably robust, exposed to a broad range of temperatures as well as some pretty rocky terrain. The rover also has a Bio-UltraViolet Fluorescent instrument (BUF) composed of light-field cameras that can focus at multiple depths. The UV causes organics to fluoresce,indicating the abundance of organic materials in the samples.

Nathalie Cabrol of the SETI Institute, remarked "we can now provide astrobiology with a highly mobile drill-mounted rover that is able to test for the possibility of life on Mars" By punching holes down to 80 cm, Zoe can get better access of the record of life on Mars than the MER Opportunity or the MSL Curiosity rovers now on Mars."

After this year's field campaign, the engineers have a list of improvements and refinements they need to make on the rover and its instruments. Next year they plan to take Zoe even farther afield, following a east-west transect across Chile into different elevations and environmental conditions, and hopefully generating even larger science returns.

Mars Curiosity Begins Autonomous Navigation

www.marsdaily.com/reports/Mars_Curiosity_Debuts_Autonomous_Navigation_999.html

September 3, 2013 - Editor: After more than a year of operating on transmitted daily "gameplans" sent each Martian night from the control lab at NASA's JPL - we couldn't take chances until Curioisty had safely filled the primary goals of its mission - we are confident that Curiosity's autonomous navigation system can be trusted to operate safely with no, or few, hiccups.

NASA's Mars rover Curiosity has used autonomous navigation for the first time, a capability that lets the rover decide for itself how to drive safely on Mars. This latest addition to Curiosity's array of capabilities will help the rover cover the remaining ground en route to Mount Sharp, where geological layers hold information about environmental changes on ancient Mars.

The capability uses software that engineers adapted to this larger and more complex vehicle from a similar capability used by NASA's Mars Exploration Rover Opportunity, which is also currently active on Mars. Using autonomous navigation, or **autonav**, Curiosity can **analyze images it takes during a drive to calculate a safe driving path**. This enables it to proceed safely even **beyond the area that the human rover drivers on Earth can evaluate ahead of time**.

The key test

On Tuesday, August 27, Curiosity successfully used autonomous navigation to drive onto ground that could not be confirmed safe before the start of the drive. This was a first for Curiosity. In a preparatory test last week, Curiosity plotted part of a drive for itself, but kept within an area that operators had identified in advance as safe.

"Curiosity takes several sets of stereo pairs of images, and the rover's computer processes that information to map any geometric hazard or rough terrain. The rover considers all the paths it could take to get to the designated endpoint for the drive and chooses the best one."

How it used to be (from the Editor, not the article cited above)

As you can imagine, controlling a robot on another planet takes more than just a joystick and a pair of radio antennas. The teams are made up of many people working together to carry out the missions. The difficulties they face are literally astronomical.

For a start they have to deal with the distance.The speed-of-light delay is the lag in sending signals between Earth and Mars. The orbits of our two planets are elliptical and uneven so the distance from here to there fluctuates from around 36 million to over 250 million miles apart. With this approximate range it takes a radio signal between 3 to 22 minutes to reach the receiver so the craft has to completely guide itself during landing. That's exactly why Wind River's VxWorks code was so crucial. A controller wouldn't know whether their action worked until a second signal had been sent all the way back to earth. To deal with this issue the team meets daily to organize a sequence of actions for the rover for the upcoming Mars day, that they will send in one transmission. Then, using an avatar of the rover in a computer generated environment, they navigate the machine and instruct it to perform its tasks. Once the transmission is sent they have to wait, and, at the end of the day, the rover sends back another single transmission with all the days data and reports.

At first, the teams tried to operate on "Mars Time." Mars "day" or "sol" is 39 minutes longer than ours. For the first month after Curiosity landed, the team got to work 40 minutes later than the day before. By the end of the first month, the sense of slow continual "jet lag" was too much and they rebelled. They insisted on working on Earth Time (Pacific Time in this case) but that caused its own problems.

(9-28-2012 **Rover Team Fights Jet Lag** - http://www.space.com/17815-mars-rover-jet-lag.html)

The decision to trust Curiosity to make some of its own decisions marks a milestone in robot autonomy. If it goes well, **August 27, 2013**, the mission's 376th "sol," will be one to celebrate.

This day took Curiosity across a depression where ground-surface details had not been visible from the location where the previous drive ended. The drive included about 10 m (33 ft) of autonomous navigation across hidden ground as part of a day's total drive of about 43 m (141 ft). "We could see the area before the dip, and we told the rover where to drive on that part. We could see the ground on the other side, where we designated a point for the rover to end the drive, but Curiosity figured out for herself how to drive the uncharted part in between," said JPL's John Wright, a rover driver.

For more, see the linked page at the top of this article. **For related stories check**
http://www.space.com/22647-**mars-rover-safer-drive-software**.html

http://www.marsdaily.com/reports/
Upgrade_to_Mars_rovers_could_aid_discovery_on_more_distant_worlds_999.html

Next Mars Rover Should Be a Souped-Up Curiosity, NASA Panel Says

http://news.sciencemag.org/scienceinsider/2013/07/**next-mars-rover-should-be-a-soup**.html

[Editor's summary. For the full article see the link cited above]

July 9, 2013 NASA has a blueprint for the kind of rover that it should send to Mars in 2020. Following a panel's recommendations, the 2020 rover would look a lot like Curiosity, which is now surveying the planet. But it would have **a host of new capabilities** to enable a detailed investigation of the martian surface. And it would **create a cache of martian soil samples to be brought back to Earth in the future.**

"The action really is still on the surface of Mars. We really need to go back to the surface and go to the next stage in answering whether there was ever any life on Mars."

Six months ago, Grunsfeld tasked a science definition team to outline the concept for a 2020 mission to explore Mars. Led by Brown University planetary scientist John Mustard, that team has now delivered a report that lays out what the next rover should be equipped to do.

- Instruments that will not only take broad pictures of sites on the surface but also take more detailed images of rocks and geological features.
- Instrumentation to allow for fine-scale imaging and fine-scale mineralogy, especially of rocks through which water might have flown in the past.
- Instruments that would enable chemical analysis and the detection of organic carbon.
- Technology to drill rocks and create a cache of at least 31 samples for later recovery.

With this incredibly powerful set of tools, we can seek out evidence of past life on Mars. And the cached samples—if ever brought back to Earth—"would address an enormous number of science questions" not just about possible existence of life on Mars, but also Mars evolution as a habitable world.

Modeling the rover on Curiosity will keep costs down. It could be built for $1.5 billion, about $1 billion less than what Curiosity cost. Whether there will be enough money for NASA to begin seriously planning for the 2020 mission is another question. ##

Odd Martian crater type made by impacts into ancient ice

Aug 5, 2013 - http://phys.org/news/2013-08-**odd-martian-crater-impacts-ancient**.html

[Editor's summary. For the full article see the link cited above]

Double-layer ejecta craters could form when ejected material slides down steep crater walls and across ice, forming a top layer. Striations, common in landslides on Earth, radiate out from the crater rim. Credit: NASA

Brown University geologists have developed a promising new explanation for the mysterious double-layered ejecta craters or DLEs. Like other craters, DLEs are surrounded by debris excavated by an impactor. The debris forms two distinct layers—a large outer layer with a smaller inner layer sitting on top. These distinctive craters were first documented in data returned from the Viking missions in the 1970s, and scientists have been trying ever since to figure out how the double-layer pattern forms.

A new study by graduate student David Kutai Weiss and James W. Head, professor of geological science, suggests that DLEs, discovered in the 190s, are the result of impacts onto a surface that was covered by a layer of glacial ice tens of meters thick. "Recent discoveries by planetary geoscientists have shown that the climate of Mars has varied in the past,. During these times, polar cap ice is redistributed into the mid-latitudes of Mars as a layer about 50 meters thick, in the same place that we see that the DLEs have formed. This made us think that this ice layer could be part of the explanation for the formation of the unusual DLE second layer," Head said.

In this scenario, the impact blasts through the ice layer, spitting rock and other ejecta out onto the surrounding ice. But because that ejected material sits on slippery ice, it doesn't all stay put. Weiss and Head believe the layering occurs when material near the top of an upraised crater rim slides down the slippery ice and overtops material on the lower slopes. That landslide, enabled by steep slopes and a slick ice layer, creates the DLEs' telltale two-layered appearance. ##

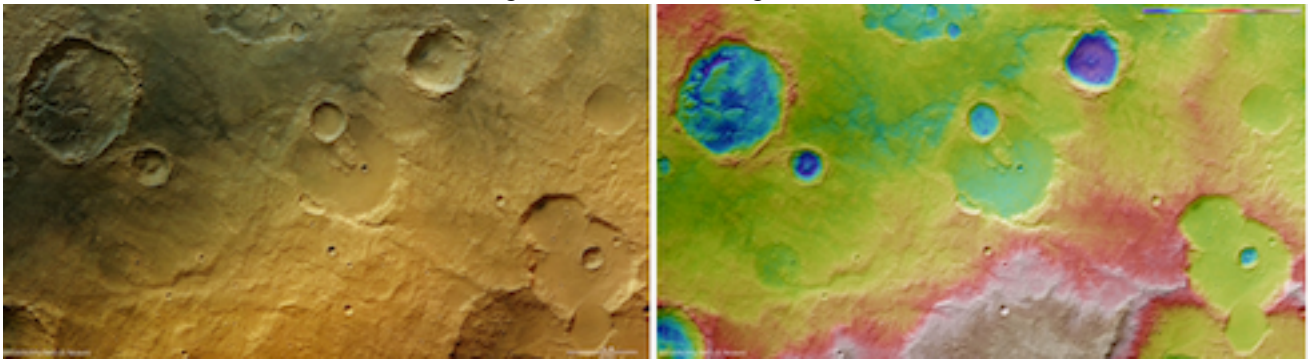
Fly through Hebes Canyon on Mars, Now! - Video!

www.esa.int/Our_Activities/Space_Science/**Fly_through_a_canyon_on_Mars** - **a must watch!**

Once There was Water in a Martian Desert

http://www.esa.int/Our_Activities/Space_Science/**Mars_Express/Water_in_a_martian_desert**

[To see the condensed images below in their original size, see the article above]



Left: Searching for water near Tagus Valles **Right**: Colour-coded topography of Tagus Valles region

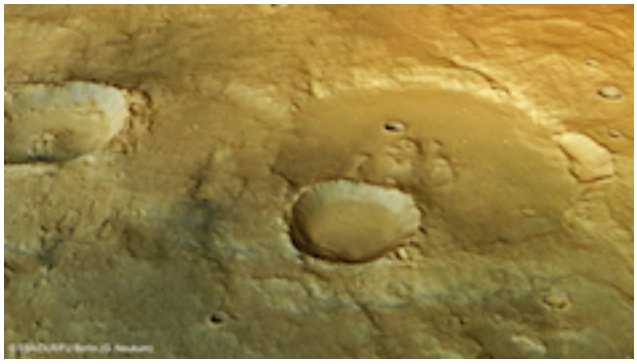
August 1, 2013 - Craters once brim-full with sediments and water have long since drained dry, but traces of their former lives as muddy lakes cling on in the martian desert.

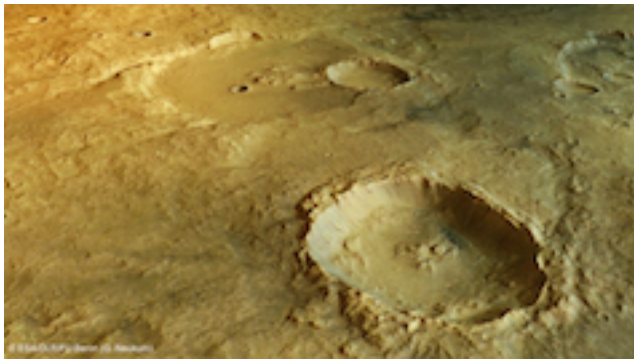
The images taken on 15 January by ESA's Mars Express, feature a region just a few degrees south of the equator within the ancient southern highlands of Mars. The unnamed region lies immediately to the north of an ancient riverbed known as Tagus Valles and east of Tinto Valles and Palos crater.

The 34 km-wide crater in the top left of the main images perhaps draws most attention with its chaotic interior. Here, broad flat-topped blocks called mesas can be found alongside smaller parallel wind-blown features known as yardangs. Both mesas and yardangs were carved from sediments that originally filled the crater, deposited there during a flood event that covered the entire scene. Over time, the weakest sediments were eroded away, leaving the haphazard pattern of stronger blocks behind.

Further evidence of a watery past is seen in the top right of the crater in the shape of a small, winding river channel. There is a ghostly outline of an ancient crater some 20 km to the east. While the crater has all but been erased from the geological record, a long meandering channel clearly remains, and flows towards the crater in the centre of the scene.

This central complex of craters is seen close up in the perspective view below, showing in more detail another channel-like feature, along with a highly deformed crater. The rim of this eroded crater may have been breached as sediments flooded the larger crater.





Left: Deformation in a flooded crater **Right**: Landslides inside a crater

Numerous landslides have occurred within this crater, perhaps facilitated by the presence of water weakening the crater walls. Grooves etched into the crater's inner walls mark the paths of tumbling rocks, while larger piles of material have slumped en-masse to litter the crater floor. A group of interconnected craters with flat floors smoothed over by sediments lie in the lower right part of the main image. One small crater with a prominent debris deposit – an ejecta blanket – lies within the crater.

Ejecta blankets are composed of material excavated from inside the crater during its formation. This crater exhibits a 'rampart' ejecta blanket – one with petal-like lobes around its edges, evidence that liquid water bound up in the ejecta allowed it to flow along the surface, giving it a fluid appearance.

Volcanic eruptions have also left there mark. Dark fine-grained ash covers the top left corner of the main image and may have been deposited from the Elysium volcanic province to the northeast. Over time, the ash was redistributed by wind, and buried deposits exposed in localised areas by erosion. ##

Alien Life Hunt on Mars Looks to Earth's Underground Microbes

http://www.space.com/22188-alien-life-search-microbes-underground.html

[Editor's summary. For the full article see the link cited above]

[This article is relevant to the search for life anywhere, but it is most timely for the search for life on Mars]

July 21, 2013 - Future life-seeking missions on other worlds may be in for a tough time if all evidence of past or present life is below the surface. Jan Amend is studying microbes that live underground on Earth

Meanwhile, hundreds of millions of miles away on Mars, the Curiosity rover is looking for clues to a suitable environment for life might that once may have existed on this now seemingly desolate planet. Curiosity can only scratch the surface: its drill penetrates mere centimeters below the ground. Any evidence of past or present life is likely hidden deep within the subsurface. Future missions to Mars will need equipment to detect and study any subsurface microbial life. That equipment will need to be perfected and tested here on Earth first.

The NASA Astrobiology Institute awarded a grant in January 2013 to Jan Amend, of the University of Southern California, who specializes in microbiology. In April 2013 he gave a talk outlining the ambitious objectives that he and his team hope to achieve over the next five years.

Journey to the center of the Earth

We believe that a large portion of Earth's biomass is locked up underground, both below the oceans and the continents. The first part of the mission will be to gain access to the subsurface below land, and there are already many potential pre-existing boreholes lined up. The Nevada national security site is littered with over 800 bomb blast craters, but it also has holes that were drilled and never used. These can now become a window to the subsurface. This is still a number of years away.

Another option is to test samples up that nature brings to the surface from deep-sourced springs. Experiments needn't be lowered down these springs, as the fluids bubbling up from the depths will do. In selecting the best range of sites, their geology, temperature, pH and chemistry are important. "The idea is to characterize the subsurface biosphere in a number of different environments," Amend said.

Detecting life in the deep subsurface

To detect and characterize any microbial life in its natural habitat, the team will be using deep ultraviolet microscopy both within the borehole and in the lab. The instrument that takes the journey down the borehole is the Subsurface Exploration and Assessment of Life (SEAL) microscope. SEAL can detect microbes on site, and it is already in use in marine subsurface studies.

Using deep ultraviolet microscopy has big advantages. The technique is non-invasive, so that the sample remains perfectly intact, and no direct contact is needed with the sample.

The next goal is cultivation of the microbes, something that has taken a backseat in microbiology for a long time. "Our approach is to use a variety of different cultivation techniques to try to cultivate some of those difficult-to-culture organisms." Many microbes may be just uncultured, not unculturable.

For more of what scientists plan in this fascinating endeavor, read the full article, link above. ##

NASA Begins Launch Preparations for Next Mars Mission: MAVEN

http://www.nasa.gov/press/2013/august/**nasa-begins-launch-preparations-for-next-mars-mission**/

http://www.nasa.gov/**maven**

video: http://www.youtube.com/watch?v=OeFaHNVujB4&feature=player_embedded

[NASA's **M**ars **A**tmosphere and **V**olatiles **E**volution (**MAVEN**) spacecraft inside the Payload Hazardous Servicing Facility on August 3. 2013 at Kennedy Space Center in Florida. MAVEN is being prepared inside the facility for its scheduled November launch to Mars.]

NASA's next Mars-bound spacecraft arrived in a cleanroom at Kennedy Space Center on August 2nd to begin final preparations for its November launch. MAVEN is now undergoing detailed testing and fueling prior to being moved to its launch pad for a 20-day launch period Nov 18 - Dec 7.

This will be the first mission dedicated to surveying Mars' upper atmosphere, to obtain data that will help us understand how the loss of atmospheric gas to space may have played a part in changing Mars' climate over billions of years.

Previous Mars missions detected energetic solar fields and particles that could drive atmospheric gases away from Mars. Unlike Earth, Mars does not have a planet-wide magnetic field that would deflect these solar winds. As a result, these winds may have stripped away much of Mars' atmosphere. MAVEN's data will help to reconstruct the planet's past climate, projecting how Mars became the cold, dusty desert planet we see today. The one-year mission begins when MAVEN enters Mars orbit in September 2014.

"MAVEN is not going to detect life. But it will help us understand the climate history, which is the history of its habitability." ##

Torpor (Suspended Animation} Inducing Transfer Habitat For Human Stasis To Mars

www.nasa.gov/content/**torpor-inducing-transfer-habitat-for-human-stasis-to-mars**/#.Uh_dOha0Lww

[Editor's summary. For the full article see the link cited above]

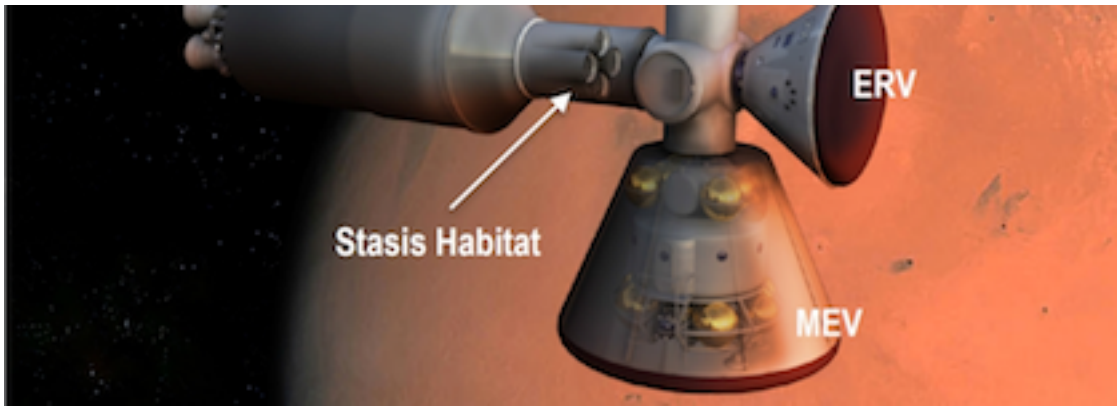
{The NASA Innovative Advanced Concepts (NIAC) Program is proud to announce its 2013 awards. NIAC has selected twelve new Phase I awards and six new Phase II awards. These proposals have been selected based on the potential of their concepts to transform future aerospace missions, enable new capabilities, or significantly alter and improve current approaches. Each Phase I study will receive approximately $100,000 for one year, and each Phase II study will receive approximately $500,000 for two years. These studies will advance numerous innovative aerospace concepts, and help NASA achieve future goals.]

The following is a phase I award

The idea of **suspended animation** for interstellar human spaceflight has often been posited as a promising far-term solution for long-duration spaceflight. A means for full cryo-preservation and restoration remains a long way off still. However, recent medical progress is quickly advancing our ability to induce **deep sleep states (i.e. torpor) with significantly reduced metabolic rates** for humans over extended periods of time. NASA should leverage these advancements for spaceflight as they can potentially eliminate a number of very challenging technical hurdles, reduce the IMLEO for the system, and ultimately enable feasible and sustainable missions to Mars.

SpaceWorks proposes the **design of a torpor-inducing Mars transfer habitat** and an architectural-level assessment to fully characterize the impact to Mars exploration. The habitat is envisioned as a very small, pressurized module that is docked around a central node/airlock permitting direct access to the Mars ascent/descent vehicle and Earth entry capsule by the crew.

Reducing habitat and life support mass



We believe the crew habitat mass can be reduced to only 5-7 metric tons (for a crew of 4-6), compared to 20-50 metric tons currently. The total habitat module volume would be on the order of 20 cubic meters, compared to 200 cubic meters for most current designs.

An end-to-end Mars mission architecture will be evaluated using the new habitat design. Technology assumptions being used in other ongoing NASA studies will be used for comparisons. This human-stasis option will then be compared with various Design Reference Architectures (DRAs) to quantify the impact and merits of the approach. ##

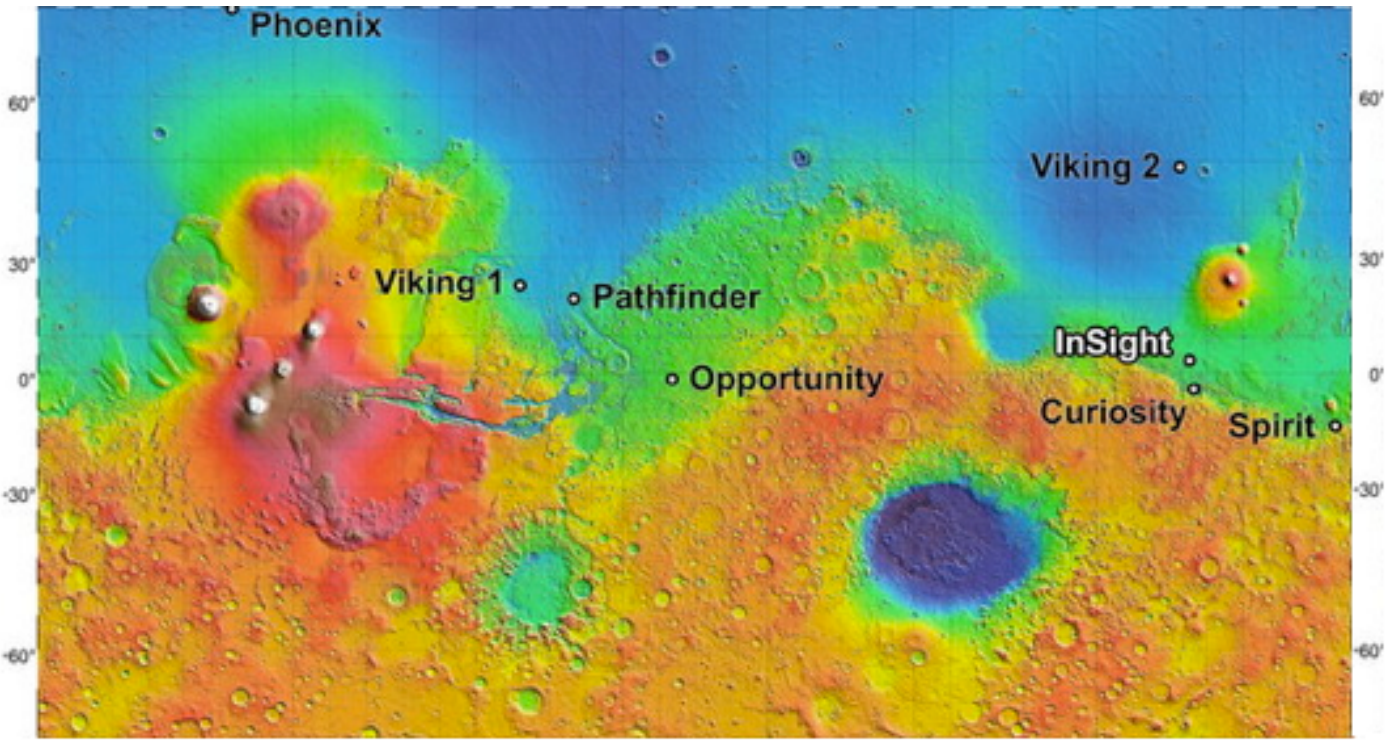
Editor's Comment:

(1) This mass reduction is helpful. While it will not reduce the mass of food and water brought along for consumption on Mars, by reducing total mass, we could either send a larger better equipped mission with the same rocket, or send the original amount on a smaller rocket, which may mean getting the first human crew to Mars, sooner!

(2) IN Moon Miners' Manifesto #30, November 1989, in the article "**Wanted: Split personality types for Mars Expedition**" - and in MMM #213 March 2008, in the article "**~~Killing Time~~ Productively on the Way to Mars and on the Return to Earth"** we would have an "awake" crew putting the many months on the way to Mars (and back) to good use. Both articles are reprinted in the **MMM Mars Theme collection**, a free download pdf file: http://www.moonsociety.org/publications/mmm_themes/mmmt_Mars.pdf

Using the Torpor approach, such make-work exercises would not be necessary, though still helpful. A compromise would be to have 2 crew members awake, and so occupied, either the same two for the whole trip, or taking turns in rotation. PK

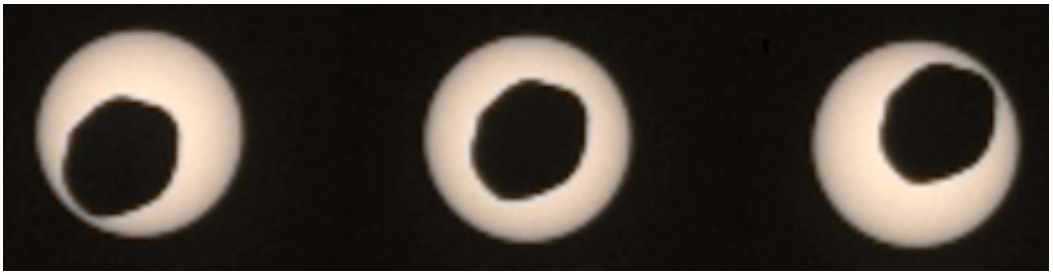
Other Links: http://en.wikipedia.org/wiki/Suspended_animation
http://www.**ted.com**/talks/mark_roth_suspended_animation.html (video)
http://singularityhub.com/2011/09/14/aint-no-science-fiction-suspended-animation-is-fda-approved-and-heading-to-clinical-trials/
http://guardianlv.com/2013/07/nasa-funding-suspended-animation-and-11-other-cool-ideas/.



No probe has visited Valles Marineris (Mars' very Grande Canyon) or Mars' major volcanoes, their flanks riddled with lava tubes, nor Mars deepest basin, Hellas Planitia where air pressures is highest (where plants bred for Mars conditions will first take hold, and where we will first be able to fly on Mars.)

Apparently, what catches the tourist's eye is not what zaps a scientist's curiosity!. ##

Phobos eclipses the Sun: Photo taken by Curiosity – August 20, 2013



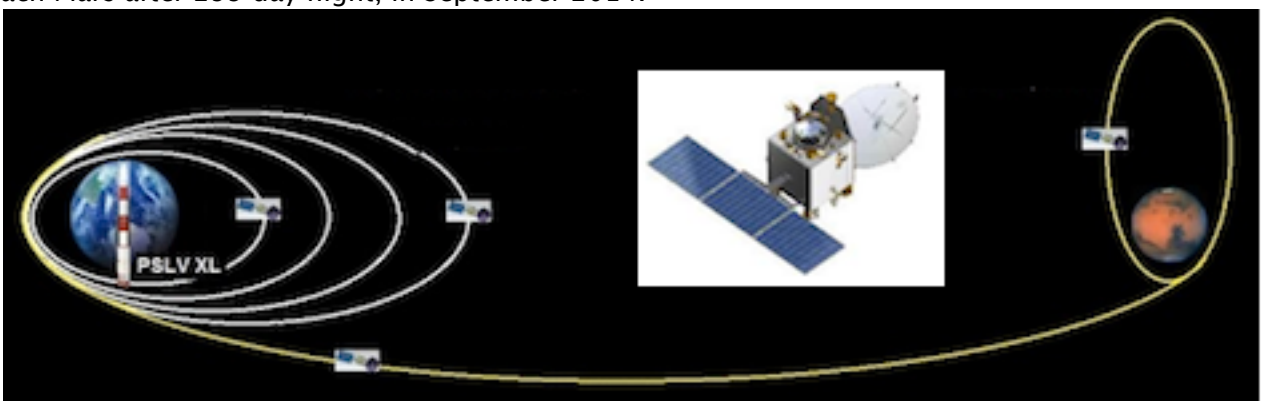
http://www.space.com/22685-**mars-solar-eclipse-curiosity-rover-videos**.html

Little Phobos makes a big silhouette, not because it is big, but because it is so close to Mars surface.

India prepares for November Launch of Mars Probe Mangalyaan

http://www.marsdaily.com/reports/**India_prepares_to_launch_countrys_maiden_mission_to_Mars**_999.html
http://www.nytimes.com/2013/09/12/world/asia/**a-vision-for-india-why-not-go-to-mars**.html

September 9, 2013 - The powerful PSLV-XL launch vehicle will launch the "**Mangalyaan**" Mars probe from the Indian Space Research Organization's launch site at Sriharikota in SE India, north of Chennai. It is expected to reach Mars after 299 day flight, in September 2014.

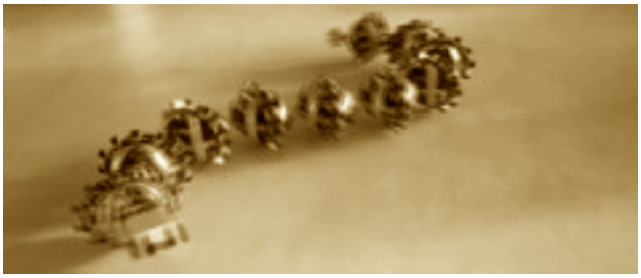


A Chinese probe, hitching a ride aboard a Russian probe to Mars' moon Phobos, never got further than Earth orbit as the Russian probe's engines failed to fire in November 2011.

The main objective of India's first mission to Mars is **detection of methane on Mars using the methane senso**r, for detection of life on the planet. - http://en.wikipedia.org/wiki/**Mangalyaan**

"Slithering" "Snake" robots on Mars could negotiate Rough Terrain

http://now.msn.com/scientists-want-to-send-s**nake-robot-to-mars**
http://www.space.com/22834-**snake-robots-on-mars-how-they-could-look-video**.html



"Scandinavian-based Foundation for Scientific and Industrial Research (SINTEF) believes a great alternative to Mars' rovers maybe slithering robotics. They are working with Norwegian company Robotnor on many uses for the robots." They would be better able to negotiate obstacles in rugged terrain, and would be able to pick and test their own route choices around and through rough areas.

Curiosity found evidence of "abundant" "fresh" water on Mars. eons ago

http://www.space.com/22854-mars-water-curiosity-rover-discoveries.html

[Editor's summary. For the full article see the link cited above]

September 18, 2013 LONDON — "Water, water everywhere, and some of it fit to drink." That's the picture of ancient Mars that has emerged during the past few months from discoveries by NASA's Curiosity rover since August 2012. The words heard most often were hydrogen, hydration, rocks and wspecially water.

"We know that on Mars there was what we interpret to be a habitable environment, where water was good enough for us to drink." Melissa Rice, of the California Institute of Technology in Pasadena,."We know that we had an initial habitable environment when these rocks formed, and then sometime later — we don't know when — these rocks had water flowing through them, through these fractures, leaving calcium sulfate behind. We don't know if that era would have also been habitable, but it tells us that there were at least two major wet stages." "Mudstones mean that you have very fine grains inside the rock — meaning that these grains settle down slowly. On Earth, that usually means that it happened because of wind or water. And we think that it was probably water." Mudstone form in a place where water has been calm, such as a lake — an ideal place for microbes to survive and reproduce.

Martian lakes?

In one of the rocks that Curiosity drilled into, there were clay minerals, implying either formation in, or substantial alteration by, water. Further, this water had to be neutral and benign. That's a big deal as far as habitability goes; Preciously, NASA's Spirit and Opportunity rovers found plenty of evidence of ancient Martian water but most of it was likely extremely acidic.

Flowing rivers?

More strong evidence of a wet past comes from Curiosity's discovery of calcium sulfate veins — a sign of a rock-forming mineral solution that has dissolved in the water, transported somewhere else and then deposited again. And then there are the ancient river deposits. An outcrop researchers dubbed Shaler. is an example of cross-stratification - thin, inclined layers of sediment such as commonly formed by rivers on Earth; turbulent water creates riverbed "dunes" that slowly migrate in the direction of the current. What Curiosity has seen are the remnants of that migration process. The water flows that produced the dunes probably occurred billions of years ago.

Will Curiosity find more water clues as it climbs Mount Sharp, its primary destination? Stay tuned!

ASTEROIDS & COMETS

Astronauts Auction Artifacts for Asteroid-Hunting Space Telescope

http://www.space.com/21847-**astronaut-auction-asteroid-hunting-telescope.html**
http://stores.ebay.com/Auction-Cause-Charity-**Auctions/B612-Foundation**.html
www.collectspace.com/news/news-070313a.html - www.collectspace.com/news/news-092612a.html

[Editor's summary. For the full article see the link cited above]

Two veteran NASA astronauts, Apollo 9 spacewalker Rusty Schweickart and former space station Flight Engineer Ed Lu, (also CEO of the Bq2 Foundation) in a bid to help protect the Earth from asteroids, are auctioning off personal space artifacts and personal mementos of their space travels to help support a private space telescope that will seek out dangerous asteroids. Up for sale are flown-in-space mission patches, flags, medals and pins to support the launch of the private Sentinel space telescope designed to discover, map, and track asteroids with orbits that approach Earth and therefore are a risk to humanity.

The B612 Foundation is a non-profit organization that is dedicated to opening up the frontier of space exploration and protecting humanity from asteroid impacts. "Not only will the money raised by this auction go to supporting the Sentinel mission, but also we hope the increased attention to our cause will help people realize that they really can take a critical role in protecting our planet in a real concrete way."

The eBay auction ran June 27 through July 7 and coincided with the one year anniversary since the B612 Foundation announced its plans for the Sentinel infrared space telescope to catalog 90 percent of the near Earth asteroids that are larger than 460 feet (140 meters). The $450 million mission is slated to launch in 2017 into a Venus-like orbit around the Sun. ##

NASA Completes First Internal Review of Concepts for Asteroid Redirect Mission

http://www.nasa.gov/press/2013/july/**nasa-completes-first-internal-review-of-concepts-for-asteroid-redirect-mission/** - http://www.americaspace.com/?p=39714

[Editor's summary. For the full article see the link cited above]

July 31, 2013 /PRNewswire-USNewswire/ NASA has completed the first step toward a mission to find and capture a near-Earth asteroid, redirect it to a stable lunar orbit and send humans to study it.

In preparation for fiscal year 2014, a mission formulation review brought together NASA leaders from across the country to examine internal studies proposing multiple concepts and alternatives for each phase of the asteroid mission. The review assessed technical and programmatic aspects.

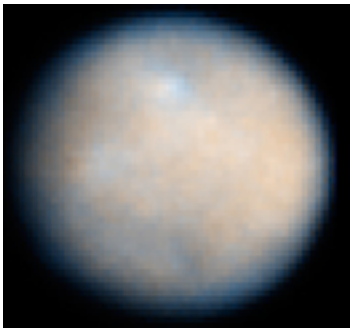
"At this meeting, we engaged in the critically important work of examining initial concepts to meet the goal of asteroid retrieval and exploration," said NASA Associate Administrator Robert Lightfoot. "The agency's science, technology and human exploration teams are working together to better understand near Earth asteroids, including ones potentially hazardous to our planet; demonstrate new technologies; and to send humans farther from home than ever before. I am extremely proud of the teams and the progress made so far. I look forward to integrating the inputs as we develop the mission concept further."

In addition to the internal reviews of concepts for the mission, managers also discussed the recently received more than 400 responses to a request for information in which industry, universities, and the public offered ideas for NASA's asteroid initiative. The agency is evaluating those responses.

Officials are now integrating the most highly-rated concepts into an asteroid mission baseline concept to further develop in 2014. The mission is included in the fiscal year 2014 budget request for NASA, and leverages progress on its Space Launch System rocket, Orion spacecraft and cutting-edge technology development. ##

Ceres Dawn Mission Updates – Arrival February 2015 – in 17 months

http://www.space.com/22722-**dwarf-planet-ceres-water-life**.html
http://www.astrobio.net/pressrelease/5427/**dawn-is-in-silent-pursuit-of-ceres**
http://**dawn**.jpl.nasa.gov – http://en.wikipedia.org/wiki/**Dawn_(spacecraft**)
http://dawn.jpl.nasa.gov/mission/status.asp

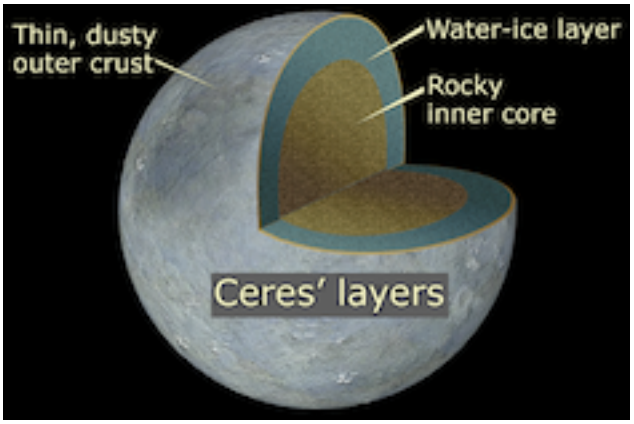


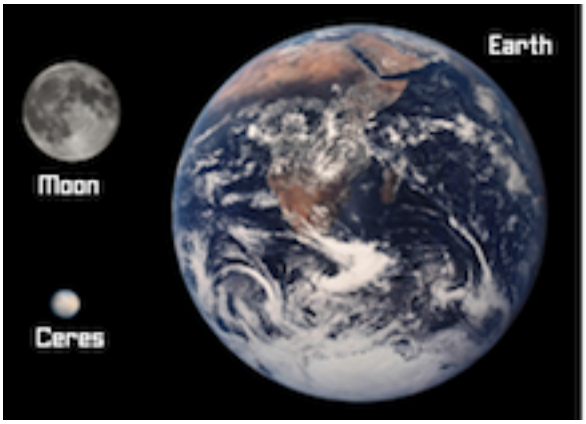
As of September 23, 2013 Dawn was at these distances:
0.1534 AU from Vesta = 28,350,000 km = 14,820,000 mi
0.2981 AU from Ceres = 44,600,000 km = 27,710,000 mi
3.24 AU from Earth = 484,700,000 km = 301,200,000 mi
2.446 AU from the Sun = 365,900,000 km – 227,400,000 mi

[1.0 **A**(stronomical) **U**(nit) = average distance between Earth and Sun: 149,600,000 km = 92,956,000 mi]

About Ceres:
http://en.wikipedia.org/wiki/**Ceres_(dwarf_planet**)
http://solarsystem.nasa.gov/planets/**profile**.cfm?Object=Dwa_**Ceres**
http://www.space.com/1526-**largest-asteroid-fresh-water-earth**.html
http://www.dailygalaxy.com/my_weblog/2013/08/asteroid-belts-**water-rich-ceres-unique-in-the-solar-system**-nasa-asks-**could-it-host-life.html**

SOME SURFACE AREA COMPARISONS: slightly larger than either of:
- all the U.S. east of the Mississippi river
- all the U.S. west of the plains states (not Dakotas through Texas)
- Queensland + Northern Territory, Australia
- All the Moon's nearside seas except the Ocean of Storms,





Musings: A Short Pool of Names for use on Ceres

Those who go to Ceres will want to name features and installations and they might find some inspiration from these historical and mythological trivia. **PIAZZI** discovered Ceres in **PALERMO**, **SICILY** on the first day of **CENTURY NINETEEN** (1/1/1801). Ceres was the Roman goddess of grain, and she chose the mortal **TRIPTOLEMUS** to carry her knowledge (the plow, agriculture) to mankind. The **AMBARVAILIA** were rites of spring celebrated by Roman farmers in Ceres' honor. – Editor ##

NASA Warned to Go Slow On Asteroid Capture Project

http://news.sciencemag.org/scienceinsider/2013/07/**nasa-warned-to-go-slow-on-astero**.html

[Editor's summary. For the full article see the link cited above]

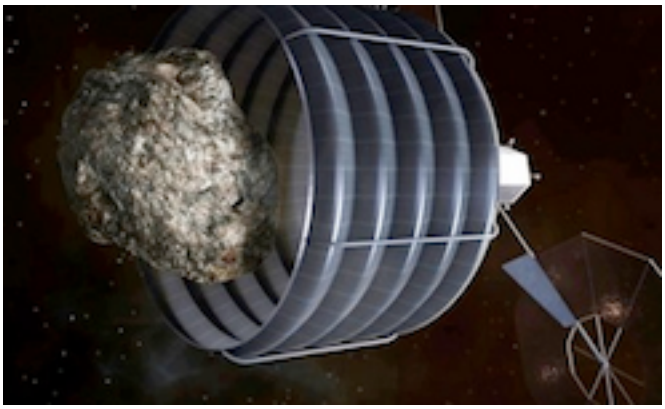
Target NEO 2: Open Community Workshop was organized by a group of planetary scientists alarmed at the way that NASA had conceived and then announced its Asteroid Retrieval Mission (ARM) in early April. [www.sciencemag.org/content/340/6133/668.summary] Some complained that NASA had acted without consulting the broader planetary science community. Many asteroid experts seriously doubted that astronomers would be able to find a suitable 8-meter, 500-tonne asteroid that a robotic spacecraft could wrangle back to orbit the Moon in time to send astronauts to sample it in the early 2020s." ##

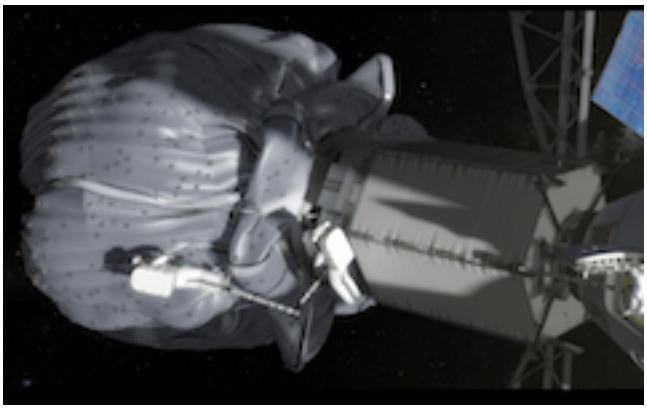
NASA Identifies 3 Potential Asteroid Targets to Catch With Space Lasso

September 12, 2013 - http://www.space.com/22764-**nasa-asteroid-capture-mission-candidates**.html
http://www.space.com/20606-**nasa-asteroid-capture-mission-images**.html
http://www.space.com/22489-**animation-of-proposed-asteroid-redirect-mission-video**.htm
i.space.com/images/i/000/027/922/i300/asteroid-return-mission-arm-130410b-02.jpg?1365628762

[Editor's summary. For the full article see the link cited above]

NASA has narrowed the list of candidates down to three space rocks for an ambitious mission to capture an asteroid and tow it to the Moon, where it can be explored by astronauts. The space agency's plan aims to bring its prize into lunar orbit using a robotic space lasso. Once there, astronauts can visit as soon as 2021 using NASA's Orion capsule and the Space Launch System rocket now under development.





NASA scientists have identified three of the best candidates from a list of 14 asteroids that could be prime contenders for this mission "It's mostly orbital constraints that those 14 satisfy," Chodas said. "We did not have the opportunity to characterize the size. We have two to three which we'll characterize in the next year and if all goes well, those will be valid candidates that could be certified targets and we'll pass by another in the year 2016. So we have three from the list of 14." NASA scientists would like to lfind about five more asteroid candidates each year before a decision must be made.

President Barack Obama in 2010. NASA's 2014 budget plan sets aside $100 million to jump-start the work on the asteroid mission. The entire project could cost up to $2.6 billion.

Size and type constraints:

NASA officials want an asteroid that is between 7 -10 meters (20-30 feet) in size, fairly small. The target size is constrained by the size of the bag and the ability of the robotic probe to bring the chunck back to the Earth-Moon system. NASA also wants an asteroid that is composed of useful materials such as a 'C-type' asteroid with hydrated (water and oxygen rich) minerals - that is the whole point. We want to be able to use such asteroids as "way-stations to extract consumables should we need that on the way to Mars, for example."

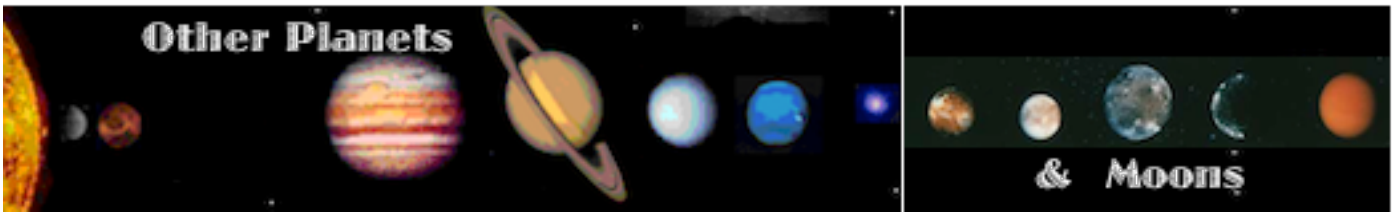
An important fringe benefit:

In the process of searching for capture candidates, we could increase the discovery rate for Earth-threatening asteroids. We need to find both types!

NASA received more than 400 proposals for the asteroid capture mission that officials narrowed down to 96 they plan on discussing in a public workshop taking place from Sept. 20 to Oct. 2. ##

2018 Inspiration Mars Mission Infographic

http://i.space.com/images/i/000/026/599/i02/**tito-mars-mission-2018**-130227c-02.jpg?1361991202



THE DAWN OF "DEEP SPACE EXPLORATION 2.0"

New Engine Could Turn Tiny CubeSats into Interplanetary Explorers

July 8, 2013 – http://www.space.com/21867-cubesat-deep-space-propulsion-kickstarter.html

[Editor's summary. For the full article see the link cited above]

"Cutting the cost of planetary exploration by a factor of a thousand"

Scientists and engineers are developing a new plasma propulsion system designed for ultrasmall CubeSats. If all goes well, they say, it may be possible to launch a life-detection mission to Jupiter's ocean-harboring moon Europa or other intriguing worlds for as little as $1 million in the next 18 months, cutting the cost of planetary exploration by a factor of a thousand. Project leader Ben Longmier, a plasma physicist and assistant professor at the University of Michigan and his team launched a crowdfunding campaign on the website Kickstarter July 4th, hoping to raise a minimum of $200,000 US, which should be enough to loft the miniature thruster on its first space voyage.

Cubesats

CubeSats, 10 cm (4") on a side, in single or multiple configurations, are both cheap and tiny spacecraft weighing just 5 kg (11 lbs) or so. To date, those sent up are in orbit around the Earth, but plans to send them to the Moon have been in the works for some time now, in the hopes of uncovering some of the Moon's closely guarded secrets that would otherwise require huge expenditures which are unlikely to be approved in the present economic climate.

Miniature thruster technology

But a new propulsion system — the **CubeSat Ambipolar Thruster, or CAT** — could change all that, turning such bantam spacecraft into interplanetary probes. CAT is a plasma engine, generating thrust by accelerating superheated ionized gas out of a discharge chamber. The CAT thruster is powered by solar panels, and permanent magnets will guide the plasma out the back of the spacecraft.

CAT is similar in concept to the ion engine that powers NASA's Dawn probe, which orbited the protoplanet **Vesta** for more than a year and is now on its way to study the Dwarf Planet **Ceres**, the largest body in the main asteroid belt between Mars and Jupiter.

Video: http://www.space.com/9933-**touring-jupiter-big-moons-io-ganymede-europa-callisto**.html

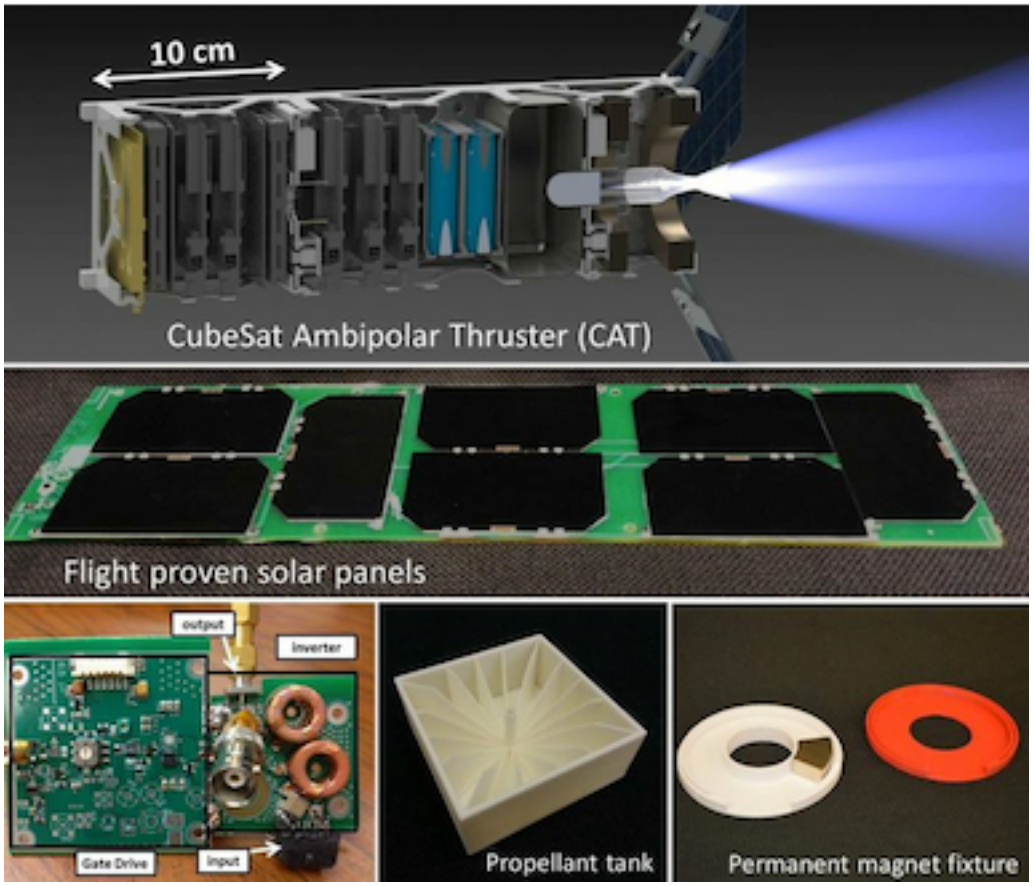
Over long periods of time, such thrusters can accelerate spacecraft to higher speeds than typical chemical rockets can achieve. But with CAT, everything must work on the micro scale. The thruster and power systems will weigh less than 0.5 kg (1 lb). The supply of propellant — likely iodine or water, though many different substances could be used — will be capped at about 2.5 kg (5.5 lbs).

Most CAT components have been built and tested individually, and the team is making good progress toward incorporating them into a unified whole.

To Earth orbit and beyond

The main goal of the new CAT Kickstarter campaign hopes to raise enough money to space-test the engine in Earth orbit within the next 18 months, if not sooner. The team plans to send the maiden CAT-equipped probe out into deep space as well, not to any target world, but far enough to demonstrate CAT's capabilities. "Our secondary goal is getting it out of Earth orbit and proving to the community that this thing works, a If it does work, it will bE a lot easier to get funding and write traditional grants.

"Raising $200,000 should make all of this possible, while meeting other funding milestones will allow the CAT team to tackle "stretch goals." If the Kickstarter campaign nets $500,000, for example, the team will fast-track its space trip by purchasing a commercial launch, while raising $900,000 will enable a two-CubeSat "space race" to escape Earth orbit."



Key Components of the CubeSat Ambipolar Thruster, or CAT

In addition to the core team at the University of Michigan, a variety of institutions are involved, including Ames Research Center in Moffett Field, Calif., the Jet Propulsion Laboratory in Pasadena, Calif., and Glenn Research Center in Cleveland, Ohio. From the commercial world, the asteroid-mining firm Planetary Resources is also onboard, interested in possibly using CAT-equipped probes to do up-close asteroid reconnaissance on the cheap, "sending a small spacecraft out as a scout, a radio beacon, to go radiotag an asteroid."

Asteroid tagging is just one of many potential applications for the technology. A fleet of CAT-powered CubeSats could also provide cheap global Internet access, or study the impacts of solar eruptions on Earth's neighborhood. Then there is the dream of sending a stripped-down, $1 million life-detection missions to Europa, flying through the plumes of Enceladus, or visiting other intriguing distant worlds within the Solar System. The team thinks all this is possible "in the relatively near future." ##

Dual-mode Propulsion System to Enable CubeSat Exploration of Solar System

http://www.nasa.gov/content/**dual-mode-propulsion-system-enabling-cubesat-exploration-of-the-solar-system**/#.Uh_hFha0Lww **- July 19, 2013 - NASA Phase I Funding Award**

[Editor's summary. For the full article see the link cited above]

While the cost of planetary exploration is rising, budgets for such missions are declining. To the rescue are newer, cheaper, low mass, systems are being developed. Small scientific "beds" which perform

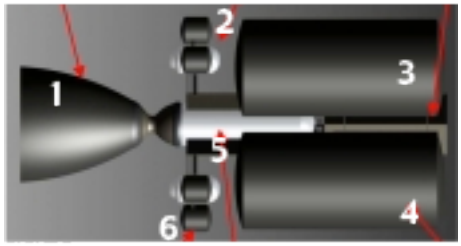
limited tasks are being developed and launched into Low Earth Orbit (LEO) in the form of small-scale satellite units, CubeSats, using solar-based power.

If a reasonable propulsion system could be developed, low cost CubeSats could be used to explore various bodies within the solar system; such as Europa. Current standard propulsion technologies, chemical-based systems, are high mass and provide insufficient performance for deep space missions. Electric propulsion (EP) is very efficient, i.e. high Isp, but has low thrust, leading to long mission times if orbital maneuvering is required. Thermal propulsion (TP) yields high thrust, but at the expense of a high consumption rate of propellant.

But pairing an EP and TP system into a dual-mode propulsion unit becomes beneficial, mating the strengths of each system when used appropriately.

- **The high thrusting capabilities of the thermal mode** are ideal for quick Earth orbit escape, drastic orbital maneuvering and orbital insertion at location.
- **The high efficiency of the electric-mode** is ideal for interplanetary travel.

Researchers at the Center for Space Nuclear Research (CSNR) are proposing a radioisotope-based, dual-mode, low mass propulsion system for a CubeSat payload capable of extending their exploration realm out of LEO. Such an integrated propulsion system would allow for beneficial exploration to be conducted, even within the current budget limitations.



1-Thermal Propulsion Nozzle 2-Electric Propulsion Thrusters 3-CubeSat Package 4-Propellant Tanks 5-Radioisotope Core 6-Propellant Tanks - [For large size image, see link below:]
www.nasa.gov/content/dual-mode-propulsion-system-enabling-cubesat-exploration-of-the-solar-system-0/#.Uh_iZxa0Lww

For the proposed work a complete system design will be provided, optimized for a Europa destination with a 10 kg payload. Modeling software such as AGI STK, COMSOL, MALTO and Aspen will be used to design and optimize the various components of the overall system. The design of an experiment will also be conducted to use existing CSNR hardware to evaluate propellant performance within the thermal mode.

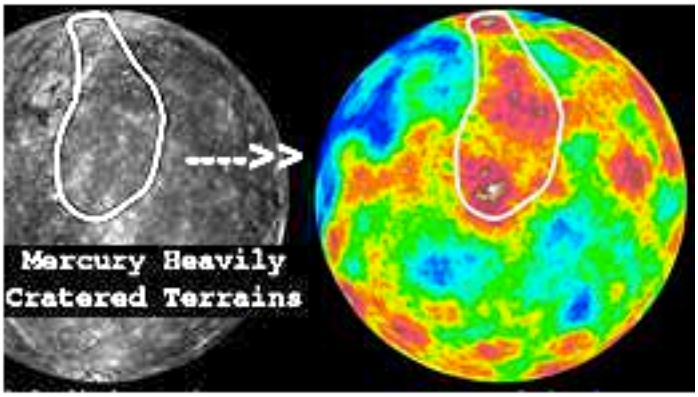
>>> **Another cutting edge propulsion story (Video only):**
www.space.com/22735-**new-nasa-ion-thruster-to-propel-spacecraft-to-90-000-mph-video.**html

MERCURY

Mercury's Volcanic Facelift Belies Planet's True Age

http://www.space.com/21836-**mercury-volcanoes-give-planet-facelift.**html
http://www.spacedaily.com/reports/
New_insights_concerning_the_early_bombardment_history_on_Mercury_999.htm

[Editor's summary. For the full article see the link cited above]



The image above shows a hemisphere of Mercury's surface: The color-coded view of the global crater areal density obtained by measuring craters greater than 25 km. The irregular area within the white

line corresponds to the heavily cratered terrains analyzed to calculate the age of the oldest surfaces on Mercury. Larger image: http://www.swri.org/press/2013/images/mercury_crater.jpg

The surface of Mercury is rather different from those of well-known rocky bodies like the Moon and Mars. Early images from the Mariner 10 spacecraft unveiled a planet covered by smooth plains and cratered plains of unclear origin.

A team led by Dr. Simone Marchi, a Fellow of the NASA Lunar Science Institute at the Southwest Research Institute (SwRI) Boulder, Colo., collaborating with the MESSENGER team, including Dr. Clark Chapman of the SwRI Planetary Science Directorate, studied the surface to better understand "if the plains were formed by volcanic flows or composed of material ejected from the planet's giant impact basins."

Recent images from NASA's MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) orbiter showed that at least the younger plains resulted from vigorous volcanic activity, but it was unclear how far into the past this volcanic activity may have occurred, or how much of the planet's surface may have been resurfaced by very old volcanic plains.

Now, a team of scientists has concluded that the oldest visible terrains on Mercury have an age of 4 billion to 4.1 billion years, and that clues to first 400 to 500 million years of the planet's evolution have been erased. The team measured the sizes and numbers of craters on the most heavily cratered terrains using MESSENGER images from its first year in orbit around Mercury. They then extrapolated to Mercury a model that was originally developed for comparing the Moon's crater distribution to a chronology based on the ages of rock samples gathered during the Apollo missions.

The study, "**Global Resurfacing of Mercury 4.0-4.1 Billion Years Ago by Heavy Bombardment and Volcanism**" was in the July 4, 2013 issue of the journal **Nature**.

"By comparing the measured craters to the number and spatial distribution of large impact basins on Mercury, we found that they (measured craters) started to accumulate at about the same time, suggesting that the resetting of Mercury's surface was global and likely due to volcanism." Those results set the age boundary for the oldest terrains on Mercury as c**ontemporary with the so-called Late Heavy Bombardment** (LHB), a period of intense asteroid and comet impacts recorded in lunar and asteroidal rocks and by the numerous craters on the Moon, Earth, and Mars, as well as Mercury.

"Meanwhile, the age of the youngest and broadest volcanic provinces visible on Mercury was determined to be about 3.6 billion to 3.8 billion years ago, just after the end of the Late Heavy Bombardment." Altogether, the results indicate that the time agreement between the onset of the LHB and the global resurfacing of Mercury implies not only that the resurfacing was due to volcanism, but also, according to Chapman, that "**the impact of large projectiles hitting Mercury's thin solid crust during the LHB may have enhanced the observed global resurfacing**." ##

JUPITER'S MOONS: EUROPA

Exploring Antarctica's Lake Vostok Analog of Europa's sub ice-crust Ocean

http://news.sciencemag.org/sciencenow/2013/07/**whats-reallygoing-on-in-lake-vos**.html

[Editor's summary. For the full article see the link cited above]

Editor's Introduction: Lake Vostok is a survivor of many thousands of years of continental glaciation in Antarctica, and remains liquid under tho - The Lake's length and width has been measured by radar as105 by 75 km (65 by 47 mi). The lake water is cradled on a bed of sediments 70 meters (230 ft) thick. The drill reached the accretion ice layer (see below) on 10 January 2013 at a depth of 3,406 m (11,175 ft) below the current ice surface of Antarctica. - http://en.wikipedia.org/wiki/**Lake_Vostok**

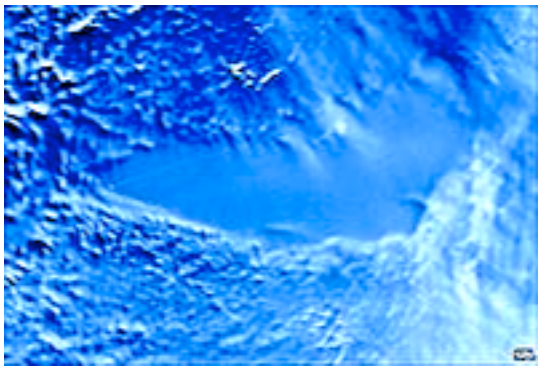
1993 that satellite-based laser altimetry—which measures surface deformation—confirmed that the lake is there. It is the largest subglacial lake on the continent.

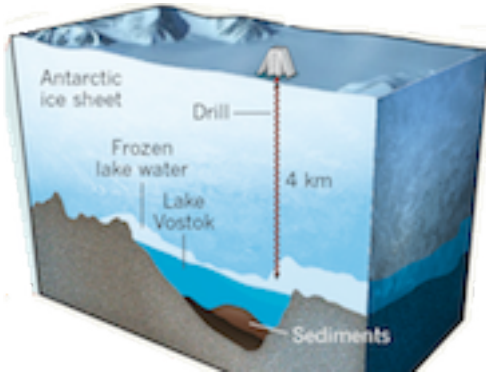
Since Lake Vostok's discovery, what life—if any—might exist within its waters has been a topic of extensive speculation. The Lake has been isolated from our atmosphere for millions of years, with limited nutrients and in complete darkness. Is it barren? Or does it contain living fossils?

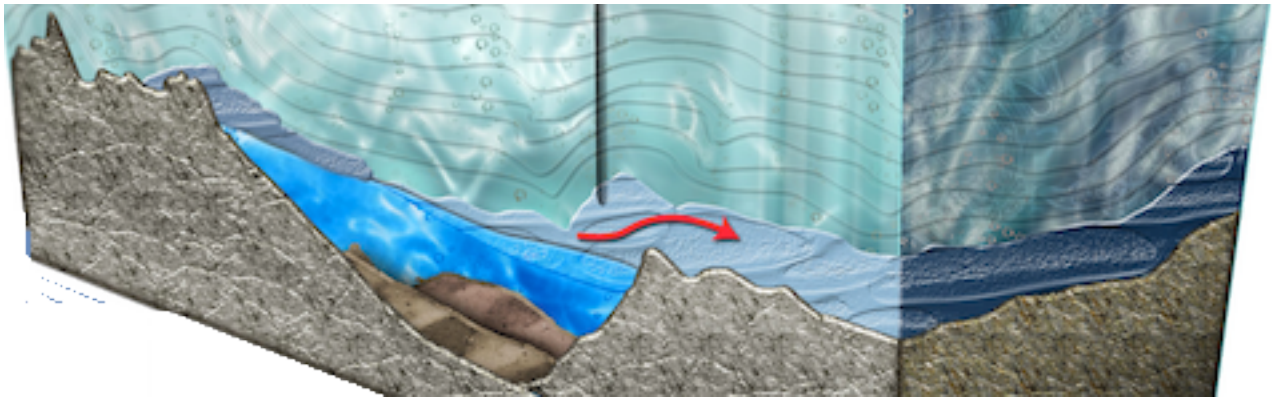
More intriguingly, what might any surviving life forms in Lake Vostok tell us about the extreme conditions in which life can thrive—not only on Earth, but potentially on other icy worlds, such as Europa? Drilling through thousands of meters of ice has been a formidable engineering task, but then there's the issue of managing to retrieve samples from the long-buried lake without contaminating them. In the past year or so scientists have obtained access to the lake itself, or rather to a layer of ice above the Lake formed from Lake Water by "accretion" and distinct from the glacial ice above.

In early 2012, after decades of drilling and strategizing about sample retrieval, a team of Russian scientists finally reached the surface of the lake. [http://news.sciencemag.org/scienceinsider/2013/01/russian-team-retrieves-first-sam.html }

"With the lake itself considered inaccessible due to fears of contamination, a number of scientists have examined ice cores taken from above the lake, focusing on the so-called "accretion ice" at the base of these cores. Accretion ice was once lake water that later froze and adhered to the overlying ice sheet—and what's in that ice might therefore provide clues to what's in the lake itself.



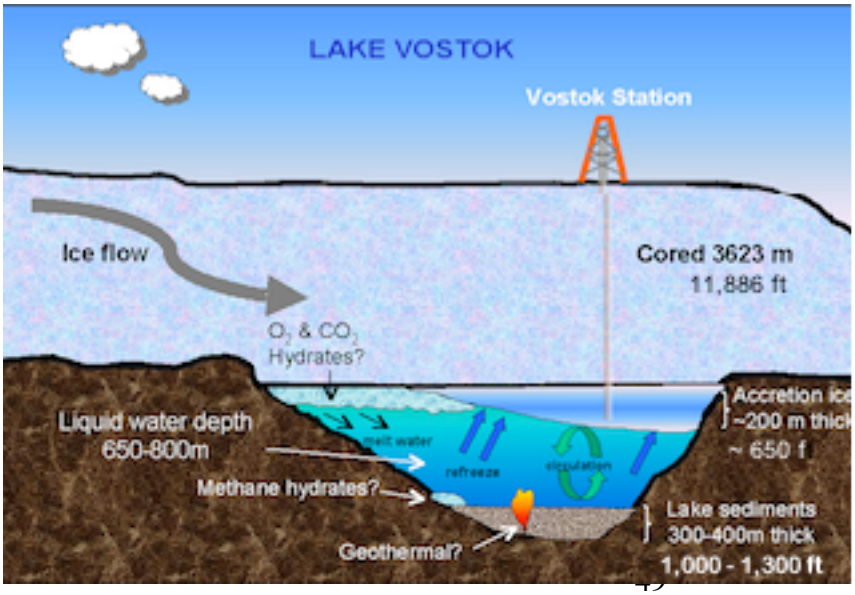


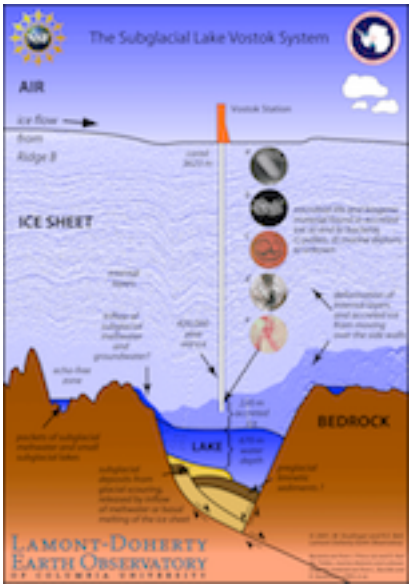


Lake Vostok is separated from the glacier itself by an "accretion layer" (red arrow) of ice from the Lake that preserves life forms from the Lake. This layer is being sampled without risk of contaminating the Lake itself below. That is, we have drilled into and sampled the accretion ice layer, without lowering the probe into the still liquid Lake itself.

In the past decade, other teams have examined microbes in the accretion ice. Overall, researchers have generally observed low concentrations of such microbes relative to most environments on Earth—but found the potential for a complex microbial ecosystem of bacteria and fungi, possibly with distinct ecological zones. For a more complete report, see:

http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0067221





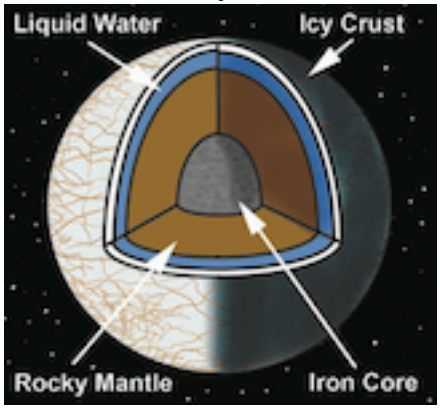
Editor's Comments:

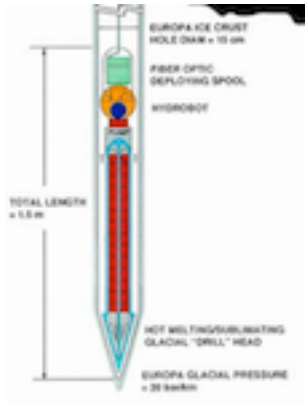
1) Lake Vostok is not really parallel to the Ocean under Europa's ice crust, because the Lake was once on the surface in a period when it could have been colonized by a plethora of surface water species.
2) Yet Lake Vostok is an example of what could survive without surface exposure, IF it originated there
3) Lake Vostok is an example of what could thrive if we found it sterile but decided to strategically populate it with appropriate primitive life forms from Earth selected to make a viable ecosystem
4) We can expect that the boundary between Europa's ice crust and the liquid ocean below (The "Rhadamanthic" after Rhadamanthes, the suitor of Europa in ancient mythology) and that means that we could sample that accretion ice layer for life forms without risk of unintentional polluting of the liquid ocean itself below. Until we have a very good idea of whether or not there are surviving life forms in Europa's global ocean, estimated to be 100 km (60 mi) deep, we must observe all due caution.

Links on proposed Probes into Europa's ocean

http://io9.com/5615286/**the-ice-fracture-explorer-a-probe-that-could-hunt-for-life-beneath-europas-frozen-crust**

http://klx.com/**europa**/





There is a recently released (August 2, 2013) Science Fiction Film about a human crew that attempts to explore Europa's Ocean: We have not yet had the chance to watch it.

"**Europa Report**" – http://www.imdb.com/title/tt2051879/

Note: sub-ice crust hidden oceans are suspected on Jupiter's largest two moon Ganymede, Callisto; Saturn's moons Enceladus and Titan, and on the dwarf planet Ceres (the closest of all the above to Earth and possibly the easiest to probe near term.)

Tiny Submersible Could Search for Life in Europa's Ocean

http://www.spacedaily.com/reports/**Tiny_Submersible_Could_Search_for_Life_in_Europas_Ocean**_999.html

[Editor's summary. For the full article see the link cited above]

One of the first visitors to Jupiter's icy moon of Europa could be a "cube-sat" type tiny submarine barely larger than two soda cans. The small craft might help strike the right balance between cost and capability for a robotic mission to look for alien life in the ocean beneath Europa's icy crust.

Artist concept of a miniature submarine exploring under the ice.
Credit: Jonas Jonsson | Angstrom Space Technology Centre of Uppsala University

The idea for “the incredible shrinking submarine” originally came from NASA's Jet Propulsion Laboratory (JPL) in California and Uppsala University in Sweden. Such a vehicle would help keep mission costs far lower. This concept also would have the advantage of only requiring a small borehole drilled through the ice surface of Europa, a few kilometers deep – we have varying estimates of its thickness..

To be able to explore previously inaccessible areas, excites Jonas Jonsson, an engineer now with Stinger Ghaffarian Technologies Inc. at NASA Ames Research Center in Moffett Field, Calif. A paper study of the miniature submersible first came from NASA JPL researchers and Greger Thornell's Swedish team at Angstrom Space Technology Centre of Uppsala University. But Jonsson, of the Swedish team, refined the submersible concept by building and testing parts of it for his Ph.D. thesis.

Scientists have gravitated toward the possibility of life on Europa ever since the Voyager 2 mission first scouted out the icy moon from afar in 1979. Voyager 2's images and data hinted at the existence of a liquid water ocean lurking beneath Europa's icy surface – a huge body of water with more volume than all of Earth's oceans combined, perhaps a hundred kilometers deep.

An idea that has captured public imagination for nearly thirty years

The intriguing prospects of possibly finding life in Europa’s safely hidden ocean was the inspiration for the sequel to Space Odyssey 2000, “**Space Odyssey 2010: The Year we made Contact**” – an American Science Fiction film by Stanley Kubrik, based on Arthur C. Clarke’s novel 2010: Odyssey Two. You can read the Plot at: http://en.wikipedia.org/wiki/2010_(film)

From Earth to Europa

The existence of Antarctic life forms found in the ice accretion area between the waters of Lake Vostok and the thousands of meters of Antarctic ice sheet above, living under extreme frigid conditions on Earth suggests that life could possibly survive below the icy crust shell of Europa as well.

Intense radiation bathing Europa’s surface means a robotic lander digging a few feet into Europa's icy surface would be most unlikely to find organic traces or signs of life. Instead, a robotic probe drlling deep beneath the icy crust to study Europa's ocean might work. But as with Lake Vostok, there may well be a shifting layer of “accretion ice formed by the freezing of the Lakes upper levels below the ice sheet, and we can look for frozen life forms in that layer without going into the liquid ocean itself and possibly “polluting” it with stowaway organisms from Earth.

Jonsson envisions the tiny submarine named Deeper Access, Deeper Understanding (DADU) taking on the Europa challenge in his 2012 Ph.D. thesis for Uppsala University in Sweden. The submarine could first get its feet wet by exploring similar watery environments on Earth where its small size could prove exceptionally useful.

> "A mission to explore Lake Vostok in Antarctica, believed to have been isolated from the rest of the world by kilometers of thick ice for millions of years, would of course be the 'Holy Grail' mission, and a real proof of concept for a future mission to explore the oceans thought to exist underneath some of the frozen moons in the solar system, such as Europa and Enceladus," Jonsson explained.

How it works

The DADU submersible would use eight small thrusters to maneuver around the underwater world. A fiber optic tether would connect DADU to a surface lander or station – a way to recharge the submersible's lithium-ion batteries and allow for remote control by a human operator. On-board software would allow the submersible to maneuver as needed.. DADU has a series of miniaturized instruments and sensors and a forward-looking camera with a small laser to capture high-resolution video and to gauge the distance, size and shape of underwater objects.

The challenge was to shrink everything down to incredibly small sizes. The sensor for measuring the conductivity, temperature and depth of water is smaller than a fingernail. The submersible's sonar device alone could fit within a “matchstick box.” It uses piezoelectric material that can vibrate to create acoustic sonar pulses and read reflected pulses or vibrations as electrical signals. The teamalso tested the idea for the submersible's sampling device for collecting tiny life forms on Europa – a microfluidic device smaller than a human thumb with a special filter to trap tiny microorganisms.

Making the future

The first prototypes of the DADU submersible were made of plastic from 3D printers that allowed the team to quickly "print" the digital designs into real objects. But tthe real submersible may be built from a titanium alloy o survive the harsh temperatures and intense pressures of underwater environments.

The team hopes to further refine the miniaturized instruments and build the full integrated systems with all the miniaturized electronics before they can seriously test the submersible's capability to survive in a frigid ocean – on Earth first, then on Europa. The team does not expect to find any showstoppers.

Getting down beneath the ice will require a mole-like drill to melt its way through the ice. The submersible would need kilometers of communications wire-tether connecting it to a surface lander or station in order to communicate with its remote human operator.

Meanwhile, the European Space Agency aims to launch **its JUpiter ICy moons Explorer mission (JUICE)** to make the first thickness measurements of Europa's icy crust starting in 2030. NASA also has begun planning a Europa Clipper mission to study the icy moon while doing flybys in a Jupiter orbit. ##

Incredible Technology: How to Explore Jupiter's Moon Europa

http://www.space.com/22146-**robotic-exploration-europa-incredible-tech**.html

[Editor's summary. For the full article see the link cited above]

Jupiter's icy moon Europa is shrouded in mystery. Scientists have long been intrigued by Jupiter's fourth largest moon with its underground ocean and icy shell. Some expect that Europa is the most likely place to find life in the solar system. But if we do find life there, will its fundamental biochemistry be the same as that on Earth or is it different? Is the origin of life easy or hard? There are all questions that Europa could potentially answer.

Building a submersible

In 2011, NASA awarded Stone Aerospace $4 million to continue the development of its "cryobot" project designed to autonomously explore Europa's ocean. How long can it operate before exhausting its power supplies? Will it be powered by a cable-tether from the surface? That might limit its range of operation to within a few kilometers of the bore hole, a teasing start. The bottom surface of Europa's ice crust may be as relatively smooth and/or as fractured as the top surface we see through telescopes and probes. Could there be "atmospheric" pockets here and there below the ice? What gasses would be trapped in those pockets? Could a submersible float and anchor itself in such a pocket?

"When we speak of the Europa mission at our shop we are talking about going for the gold ring: landing on the surface of Europa; sending a nuclear-powered cryobot carrier vehicle through the ice crust; discharging a nuclear-powered 'fast mover' autonomous underwater carrier vehicle that has planet-scale range, and selectively launching a series of miniaturized, highly intelligent AUVs [Autonomous Underwater Vehicles] to go into the more dangerous areas (e.g. around black smokers, up into ice cracks, into corrosive chemical plumes) to search for and collect biological samples and bring them back to the mother ship," Stone Aerospace CEO Bill Stone wrote told SPACE.com in an email."

"The U.S. science community is today, thanks to NASA funding, on the verge of having available portable molecular DNA sequencers that could allow a Europa AUV to characterize life found on Europa at the microbial scale and then to return to the cryobot and uplink the information to the lander and back to Earth," Stone said.

Editor's speculations

Clearly, we have more intriguing questions than satisfying answers. What we find at the end of the first borehole may well lead to additional missions, even to exploring the oceans depth levels and currents. We do not know how saline this ocean is and whether life has indeed established a foothold in it. That ignorance has made it open season for the imagination, and no one is dismissing the possibilities. We could be exploring Europa's oceanic depths for many decades to come.

And then we expect to find similar subglacial oceans below much thicker ice-crusts on Europa's larger sister moons, Ganymede and Callisto. We are sure of something similar on Saturn's smaller moon Enceladus, and suspect the same on its biggest and most unique moon, Titan.

In fact, the number of Europa-like worlds throughout the universe may vastly outnumber the Earth-like ones, and here, by Earth-like, we mean a world with surface oceans and continents.

Flybys and remote sensing

Scientists can also learn more about Europa through remote sensing, using spacecraft flybys of the moon like NASA's Galileo probe did after it arrived at Jupiter in 1995. Our next chance to do so will come with the European Space Agency's **JUICE** (short for **JU**piter **IC**y moons **E**xplorer mission) spacecraft launches in 2022 and arrive at Jupiter in 2030. JUICE will make a flyby of Europa twice and explore other moons in the Jupiter system. That seems a long time to wait for so little. But "there's a vast array of things you can learn from satellite observations of a planet," said Jeffrey Plaut, a NASA scientist at JPL. "If you're talking about Europa specifically, the science objectives have been laid out pretty clearly over the years for various space-born observations of Europa. Some very fundamental things like: How thick is the ice shell? How deep is the ocean?"

Landing on Europa

Traveling to and landing on Europa could present unique challenges.We are not sure what the surface of Europa looks like up close or how hard it will be to find a safe place to land that is also over an area where the ice crust is at its thinnest. Are their threatening ice quakes How often and how severe?

Compared to the Mars Curiosity rover's "7 minutes of terror" during the robot's sky crane descent to the Mars surface, landing a probe on Europa could be more panic-inducing. Engineers would experience "one and a half hours of terror" because of the moon's distance from Earth, and the consequent time delay between an even on Europa and when the signals from it reach Earth.

Editor's suggestion: If we had a forward base in orbit somewhere in the Jovian system, from which to teleoperate the probe lander and submersible, chances of success and/or recovery from a misadventure would be significantly greater. **The option is to build significant levels of decision-making autonomy into the probe's computer itself.**

Is Europa Habitable?" - NASA lays out science goals

http://www.spacedaily.com/reports/Is_Europa_habitable_999.html

August 09, 2013 The NASA-appointed Science Definition Team outlines the main priorities of a future lander mission to Europa to study its potential habitability in an article in Astrobiology. The article "**Science Potential from a Europa Lander**" presents three main objectives of a future mission designed to land a robotic spacecraft on the surface of Europa and to investigate its potential to support life.

1. Investigate the **composition and chemistry of Europa's ocean**;
2. Characterize the **thickness, uniformity, and dynamics of its icy shell**;
3. Study Europa's **human-scale surface geology**.

In addition, the NASA-appointed team describes the types of studies and payload of instruments recommended to achieve these objectives.

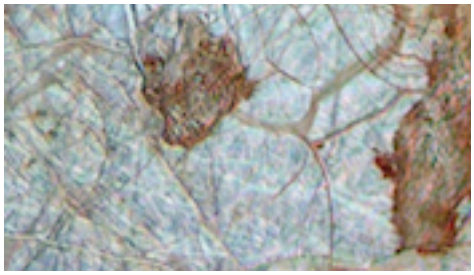
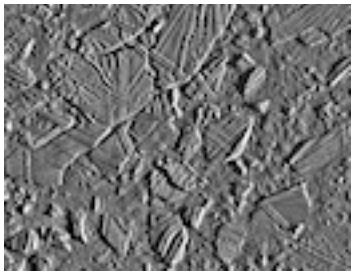
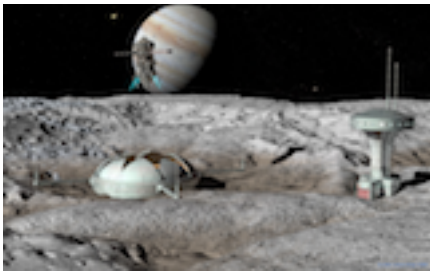
"Landing on Europa ... is a difficult technical challenge that is probably many years away. Understanding the key scientific questions to be addressed by a future Europa lander helps us to focus on the technologies required to get us there, and on the necessary data that might be attained by a precursor mission that could scout out landing sites. Europa is the most likely place in our solar system beyond Earth to have life today, and **a landed mission would be the best way to search for signs of life**."

If we landed on Europa, What would we want to know?

http://www.spacedaily.com/reports/If_We_Landed_on_Europa_What_Would_We_Want_to_Know_999.html

"If one day humans send a robotic lander to the surface of Europa, we need to know what to look for and what tools it should carry." said Robert Pappalardo, the study's lead author, based at NASA's Jet Propulsion Laboratory, Pasadena, Calif. Europa is the flatest world we know of, but that may be deceptive.

"There is still a lot of preparation that is needed before we could land on Europa, but studies like these will help us focus on the technologies required to get us there, and on the data needed to help us scout out possible landing locations. Europa is the most likely place in our solar system beyond Earth to have life today, and a landed mission would be the best way to search for signs of life."

- What makes up the reddish "freckles" and reddish cracks that stain the icy surface?
- What kind of chemistry is occurring there?
- Are there organic molecules, which are among the building blocks of life?

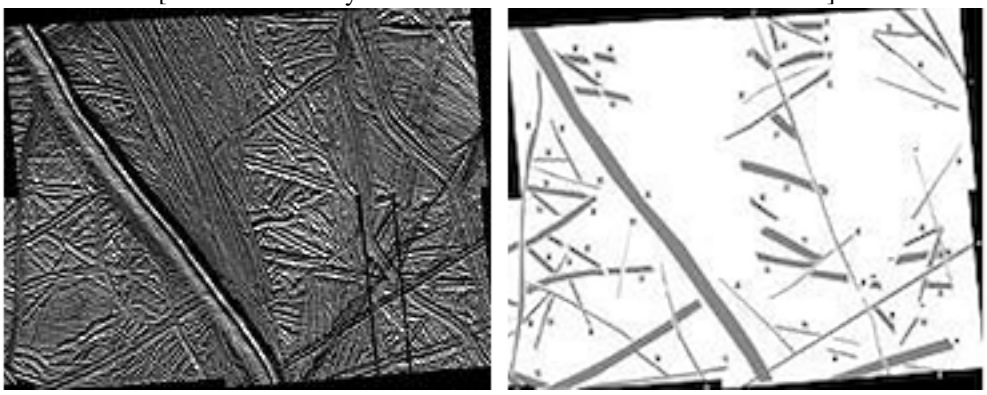
Additional priorities:

- Getting a look around at features on a human scale as context for the compositional measurements
- What current geological activity is going on in the presence of liquid water: how active is the surface?
- How much rumbling is there from the periodic gravitational squeezes from Jupiter?
- What do these detections tell us about the characteristics of liquid water below the icy surface? ##
-

Long-Stressed Europa Likely Off-Kilter at One Time

www.spacedaily.com/reports/**Long_Stressed_Europa_Likely_Off_Kilter_at_One_Time**_999.html

[Editor's summary. For the full article see the link cited above]



This close-up of the Bright Plains region near the equator of Europa reveals layer upon layer of cracks

"The puzzling part is why the cracks point in different directions over time, even though the same side of Europa always faces Jupiter."

September 24, 2013 - By analyzing the distinctive cracks lining the icy face of Europa, NASA scientists found evidence that this moon of Jupiter likely spun around a tilted axis at some point. This tilt could influence calculations of how much of Europa's history is recorded in its frozen shell, how much heat is generated by tides in its ocean, and even how long the ocean has been liquid.

It seems that a small tilt in the spin axis, sometime in the past, can explain a lot of what we see in these crack patterns. Europa's network of crisscrossing cracks serves as a record of the stresses caused by massive tides in the moon's global ocean. These tides occur because Europa travels around Jupiter in a slightly oval-shaped orbit.

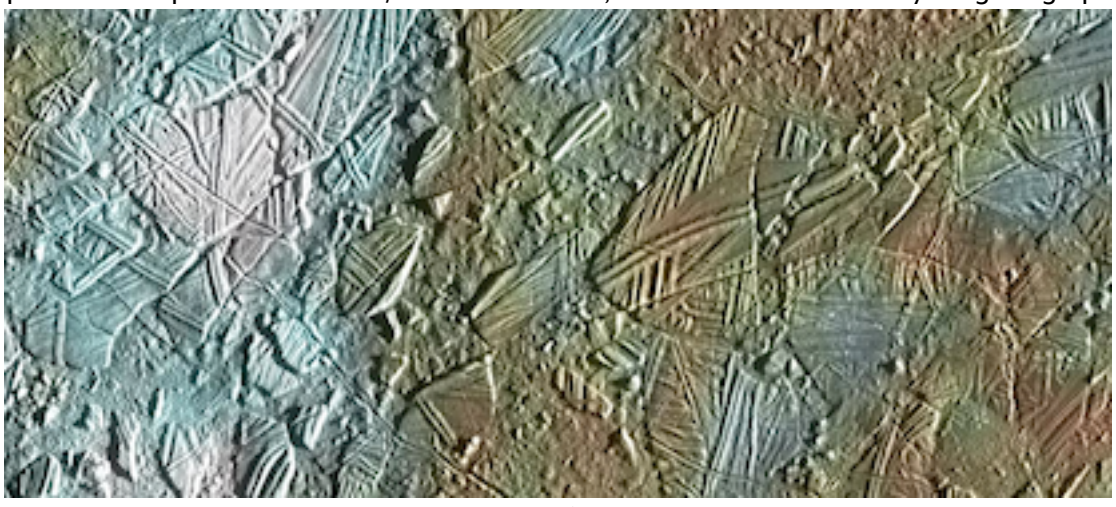
- When Europa comes closer to the planet, the moon gets stretched like a rubber band, with the ocean height at the long ends rising nearly 30 meters (100 feet).
- When Europa moves farther from Jupiter, it relaxes back into the shape of a ball.

A leading explanation has been that Europa's frozen outer shell might rotate slightly faster than the moon orbits Jupiter. If this out-of-sync rotation does occur, the same part of the ice shell would not always face Jupiter. The existence of a tilt also suggests that Europa's cracks may be much more recent than previously thought.

A tilt also could affect the estimates of the age of Europa's ocean. Because tidal forces are thought to generate the heat that keeps Europa's ocean liquid, a tilt in the spin axis might suggest that more heat is generated by tidal forces. This, in turn, might keep the ocean liquid longer.

The analysis doesn't specify when the tilt occurred. So far, measurements have not been made of the tilt of Europa's axis, and this is one goal scientists have for Europa missions in the future. ##

Editor: If we can pin down when the axis last shifted, and whether it shifts on a regular basis, we might get a good idea of how far into the future, the axis will begin to shift again. What implications that will have for any outpost on Europa's surface and/or under the ice, could be critical for any long range plan.



MEET THE "CENTAURS" – OBJECTS BETWEEN JUPITER & NEPTUNE

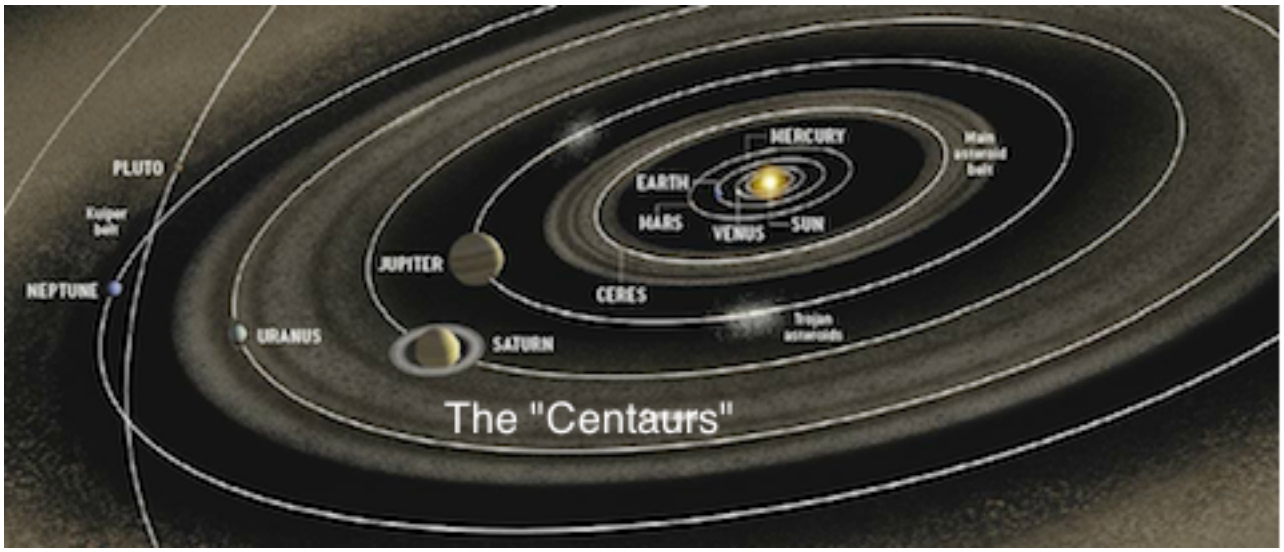
NASA'S WISE Finds Mysterious Centaurs May Be Comets

http://www.spacedaily.com/reports/prnewswire-space-news.html
http://neo.jpl.nasa.gov/programs/neowise.html
http://en.wikipedia.org/wiki/Wide-field_Infrared_Survey_Explorer

[Editor's summary. For the full article see the link cited above]

July 25, 2013 The true identity of the "Centaurs, small celestial bodies orbiting the Sun between Jupiter and Neptune, has been one of the enduring mysteries of astrophysics. Are they asteroids or comets?

A new set of observations from the Wide-field Infrared Survey Explorer (WISE) finds that **"roughly two-thirds" of the centaurs are comets**.



Until now, astronomers had been uncertain whether centaurs are asteroids flung out from the inner solar system or comets traveling in toward the sun from afar. Given this dual nature, they take their name from the creature in Greek mythology with a human head and torso and the legs of a horse.

[snip] "Our data point to a cometary origin for most of the objects, suggesting they are coming from deeper out in the solar system." Centaurs and scattered disk objects orbit in an unstable belt. Ultimately, gravity from the giant planets will fling them either closer to the sun or farther away from their current locations.

Infrared data from NEOWISE on these objects' albedos, has helped astronomers sort the population. NEOWISE can tell whether a centaur has a matte dark surface or a shiny bright one. The puzzle pieces fell into place when astronomers combined the albedo information with what was already known about the colors of the objects.

Visible-light observations have shown centaurs generally to be either blue-gray or reddish in hue. A blue-gray object could be an asteroid or comet. NEOWISE showed that most of the blue-gray objects are dark, a telltale sign of comets. A reddish object is more likely to be an asteroid. "Comet surfaces tend to be more like charcoal, while asteroids are usually shinier like the moon."

Results indicate that **roughly two-thirds of the centaur population are comets** which came from the frigid outer reaches of our solar system.

It is not clear whether the rest are asteroids. The centaur bodies have not lost their mystique entirely, but future research from NEOWISE may reveal their secrets further.

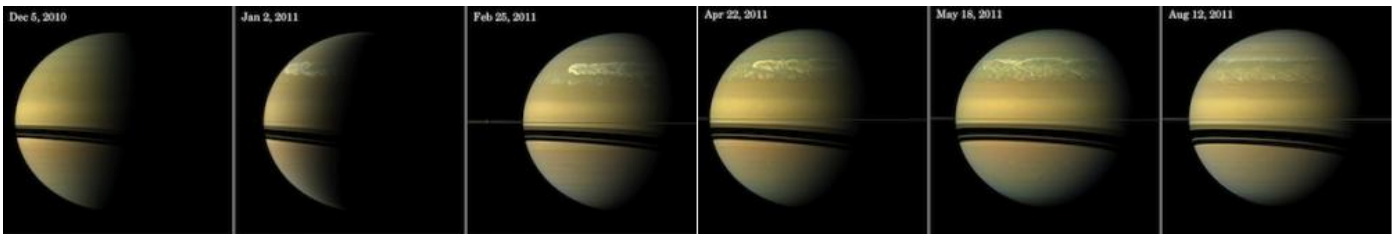
The paper is available online at: http://iopscience.iop.org/0004-637X/773/1/22/

SATURN

Massive storm pulls Water and Ammonia ices from Saturn's depths

September 3, 2013 – http://phys.org/news/2013-09-**massive-storm-ammonia-ices-saturn**.html

[Editor's summary. For the full article see the link cited above]



This series of images from Cassini shows the development of the largest storm seen on the planet since 1990. These views chronicle the storm from its start in late 2010 through mid-2011, showing how the distinct head of the storm quickly grew large but eventually became engulfed by the storm's tail.

Once every Saturnian year, a monster storm rips across the planet's northern hemisphere. In 2010, the most recent and only the 6th giant storm on Saturn observed by humans began stirring. It quickly grew to superstorm proportions, reaching 15,000 km (more than 9,300 mi) in width and visible to amateur astronomers on Earth as a great white spot dancing across the surface of the planet.

Thanks to near-infrared spectral measurements taken by Cassini and analysis of near-infrared color signatures by researchers at U. Wisconsin-Madison, Saturn's superstorm is helping flesh out a picture of the composition of Saturn's atmosphere at depths usually obscured by thick high-altitude haze. The key finding: **cloud particles at the top of the great storm are composed of a mix of three substances: water ice, ammonia ice,** and **possibly ammonium hydrosulfide**. These observations are consistent with clouds of different chemical compositions existing side-by-side, although a more likely scenario is that the individual cloud particles are composed of two or all three of the materials.

Writing in the September 9, 2013 edition of **Icarus**, a team led by UW-Madison Space Science and Engineering Center planetary scientists Lawrence Sromovsky, and including Kevin Baines and Patrick Fry, reports the discovery of icy forms of water and ammonia. Water ice had never before been seen on Saturn.

Huge thunderstorm appear to b driving these cloud particles upward, "somewhat like a volcano bringing up material from the depths and making it visible from outside the atmosphere." "The upper haze is so optically thick that it is only in the stormy regions where the haze is penetrated by powerful updrafts that you can see evidence for the ammonia ice and the water ice. Those storm particles have an infrared color signature that is very different from the haze particles in the surrounding atmosphere."

Saturn's atmosphere is believed to be a layered sandwich with a deck of water clouds at the bottom, ammonia hydrosulfide clouds in the middle, and ammonia clouds near the top, just below an upper tropospheric haze of unknown composition that obscures almost everything. This latest storm and the presence of the Cassini probe gave scientists a chance to peek beneath the haze to learn more about the dynamics and chemical composition of Saturn's deep atmosphere.

First noticed by amateur astronomers, the massive storm works like the much smaller convective events on Earth, where air and water vapor are pushed high into the atmosphere, resulting in the towering, billowing clouds of a thunderstorm. On Saturn, not only are the storms much bigger, they are far more violent, with models predicting vertical winds of more than 300 miles per hour for these rare giant storms. The effect is to loft the aerosols found deep in the atmosphere to the visible cloud tops, providing a rare glimpse of normally hidden materials. "**It starts at the water cloud level and develops a huge convective tower. similar to a big thunderstorm, only 10-20 times taller and covering more area.**"

The presence of water ice supports the idea that Saturn's superstorms are powered by condensation of water, and originate deep in the atmosphere, about 200 km below the visible cloud deck. The water could only have risen from below, driven upward by powerful convection from deep in the atmosphere. Water vapor condenses and freezes as it rises, then likely becomes coated with more volatile materials like ammonium hydrosulfide and ammonia as the temperature decreases with their ascent.

In Saturn's massive storm, the observations can be matched by having particles of mixed composition, or clouds of water ice existing side-by-side with clouds of ammonia ice. In the latter scenario, water ice would make up 22% of the cloud head and ammonia ice 55%. The remaining fraction would be made up by the third constituent, which is believed to be ammonia hydrosulfide. Up until now, there have been no quantitative calculations of spectra for cloud structures and compositions that matched the observed spectrum of an actual storm cloud feature.

For more: http://phys.org/news/2013-06-revealed-mystery-gigantic-storm-saturn.html

SATURN'S MOONS: ENCELADYS & TITAN

Forces Controlling Enceladus' Water Jets discovered by Cassini Spacecraft

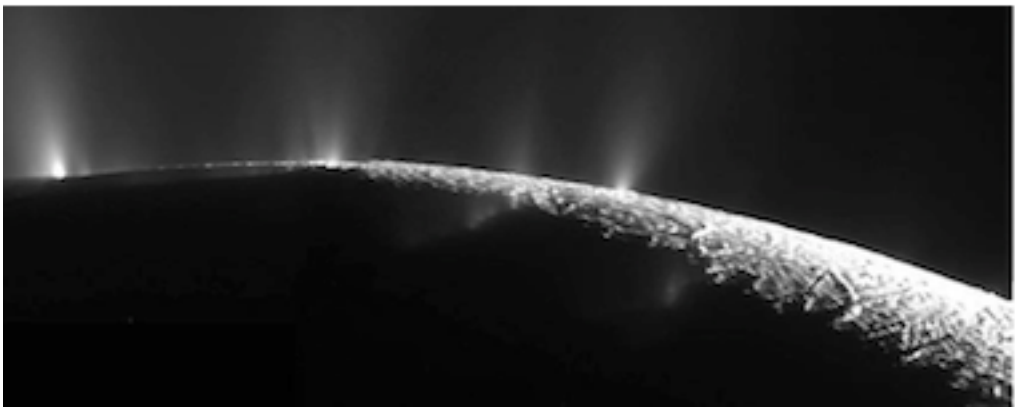
http://www.heraldonline.com/2013/07/31/5072375/nasas-cassini-spacecraft-reveals.html

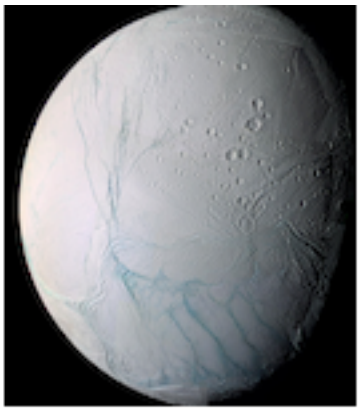
[Editor's summary. For the full article see the link cited above]

July31, 2013 The intensity of jets of water ice and organic particles that shoot out from Saturn's moon Enceladus depends on the moon's proximity to the ringed-planet, according to data obtained by NASA's Cassini spacecraft.

The finding adds to evidence that a liquid water reservoir or ocean lurks under the icy surface of the moon. This is the first clear observation that the bright plume emanating from Enceladus' south pole varies predictably. The findings are detailed in a scientific paper in this week's edition of Nature.

"The jets of Enceladus apparently work like adjustable garden hose nozzles.The nozzles are almost closed when Enceladus is closer to Saturn and are most open when the moon is farthest away. We think this has to do with how Saturn squeezes and releases the moon with its gravity."





Left: Cassini discovered the jets that form the plume in 2005, a year after it began orbiting Saturn.

Right: The water ice and organic particles spray out from several narrow fissures dubbed "tiger stripes."

"The way the jets react so responsively to changing stresses on Enceladus suggests they have their origins in a large body of liquid water," said Christophe Sotin, a co-author and Cassini team member at NASA's Jet Propulsion Laboratory. "Liquid water was key to the development of life on Earth, so these discoveries whet the appetite to know whether life exists everywhere water is present."

In search of a pattern

For years scientists wondered how and why the intensity of the jets varied over time, but no one could show that they changed in a recognizable pattern until Hedman and colleagues examined infrared data of the plume as a whole, obtained by Cassini's visual and infrared mapping spectrotmeter (VIMS), and looking at data gathered over a long period of time.

The VIMS instrument analyzes a wide range of data (including the hydrocarbon composition of the surface of Titan), as well as the seismological signs of Saturn's vibrations in its rings. VIMS collected more than 200 images of the Enceladus plume from 2005 to 2012.

A gravitational squeeze

The results show that the plumes were dimmest when Enceladus was at the closest point in its orbit to Saturn, and gradually brightened until Enceladus was at the most distant point, where it was three to four times brighter than the dimmest detection.

Adding the brightness data to previous models of how Saturn squeezes Enceladus, scientists deduced the stronger gravitational squeeze near the planet reduces the opening of the tiger stripes and the amount of material spraying out. They think the relaxing of Saturn's gravity farther away from the planet allows the tiger stripes to be more open and for the spray to escape in larger quantities.

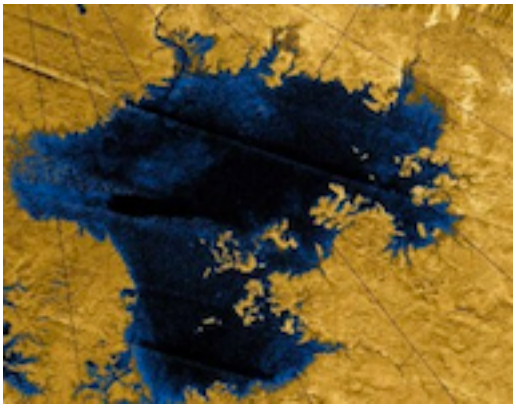
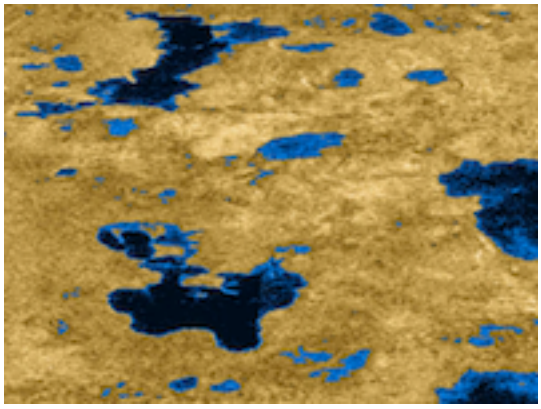
The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. JPL manages the mission for NASA's Science Mission Directorate in Washington.##

Mystery of the Missing Waves on Titan

http://www.spacedaily.com/reports/**Mystery_of_the_Missing_Waves_on_Titan**_999.html

[Editor's summary. For the full article see the link cited above]

By Dr. Tony Phillips for NASA Science News, Huntsville A (SPX) July 23, 2013

"**A wet world with its own alien waters**"

One of the most shocking discoveries of the past 10 years is how much the landscape of Saturn's moon Titan resembles Earth. Like our own blue planet, the surface of Titan is dotted with lakes and seas; it has river channels, islands, mud, rain clouds and maybe even rainbows. The giant moon is undeniably wet.

But the "water" on Titan is not H2O. With a surface temperature dipping to -179 °C (-290° F), Titan is far too cold for liquid water. Instead, researchers believe the fluid that sculpts Titan is an unknown **mixture of methane, ethane, and other hard-to-freeze hydrocarbons.**

In 2005, the European Space Agency's ESA's Huygens probe, piggybacking the ride out from Earth on NASA's Cassini Saturn orbiter, parachuted to the surface of Titan in 2005, descending through humid clouds and actually landing in moist soil.

Something has been bothering Alex Hayes, a planetary scientist on the Cassini radar team at Cornell University. If Titan is really so wet, he wonders, "Where are all the waves?" Here on Earth, bodies of water are rarely still. Breezes blowing across the surface cause waves to ripple and break; raindrops striking sea surfaces also provide some roughness. Yet on Titan, the lakes are eerily smooth, with no noticeable wave action right down to the millimeter scale, according to Cassini radar data.

Yet Titan''s great sand dunes prove that there is wind on Titan! Add to that the low gravity of Titan-only 1/7th that of Earth-which offers so little resistance to wave motion, and you have a real puzzle.

Several trial explanations

- Perhaps the lakes are frozen. But we see evidence of rainfall and surface temperatures well above the melting point of methane.
- Or maybe the lakes are covered with a tar-like substance that damps wave motion. We have no evidence to the contrary as yet/

In a study Hayes and colleagues published in the July 2013 online edition of the journal Icarus, they noted that taking into account the gravity of Titan, the low viscosity of liquid hydrocarbons, the density of Titan's atmosphere, and other factors, they could calculated how fast wind on Titan would have to blow to stir up waves: A walking-pace breeze of only 1 to 2 mph should do the trick. The mystery deepened,

This suggested a third possibility: the winds just haven't been blowing hard enough. Since Cassini reached Saturn in 2004, Titan's northern hemisphere (where most of the lakes are located) has been **locked in winter**'s grip. Cold heavy air barely stirs, and seldom reaches the threshold for wave-making.

Keep in mine that Titan's (and Saturn's) seasons are each a quarter of its 29.5 year long "year" or 7.36 years long. Cassini and Huygens have been on location for less than two seasons. But now the seasons are changing. In August 2009 the sun crossed Titan's equator heading north. Summer is coming, bringing light, heat and wind to Titan's "lake country."

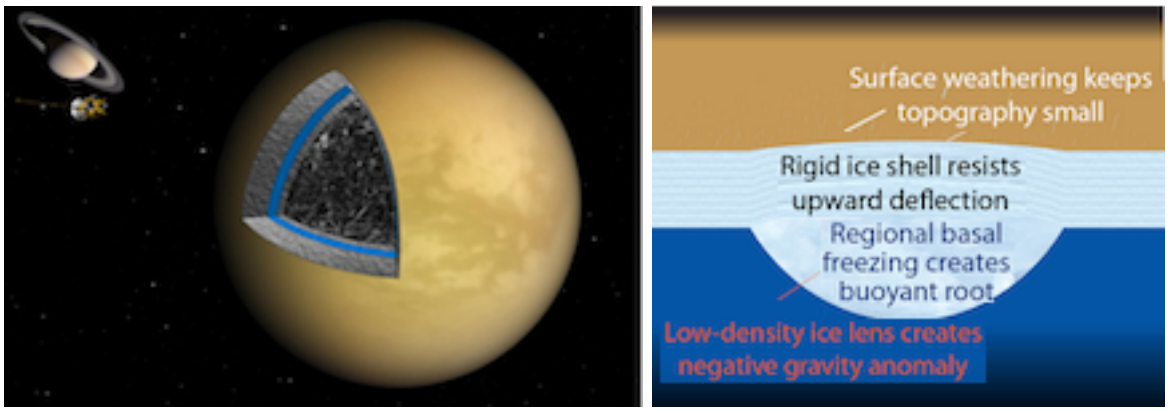
According to [climate models], winds will pick up as we approach the solstice in 2017 and should be strong enough for waves, Hayes predicts. If waves do appear, Cassini should be able to detect them. Radar reflections from wavy lake surfaces can tell researchers a great deal. Wave dimensions may reveal the viscosity of the underlying fluid and, thus, its chemical composition. Also, wave speeds would track the speed of the overlying winds, providing an independent check of Titan climate models.

Hayes is excited about "bringing oceanography to another world. All we need now," he says, "are some rough seas." (and so are we!) ##

Saturn's Moon Titan Sports Thick Icy Shell & Bizarre Interior

August 28, 2013 - http://www.space.com/22570-**titan-ice-shell-bizarre-interior**.html

[Editor's summary. For the full article see the link cited above]



This artist's illustration shows the likely interior structure of Saturn's moon Titan deduced from gravity field data collected by NASA's Cassini spacecraft. The investigation by Cassini's radio science team suggests that Titan's interior is a cool mix of ice studded with rock.

The tough icy shell of Saturn's largest moon Titan is apparently far stronger than previously thought. These unexpected findings hint that Titan possesses an extraordinarily bizarre interior.

Past research suggested that Titan has an ocean hidden under its outer icy shell 50 to 200 km (30-120 mi) thick. Investigators aim to explore this underground ocean in the hopes of finding alien life on Titan, since virtually wherever there is water on Earth, there is life.

To learn more about Titan's icy shell, planetary scientist Doug Hemingway at the U. of California, Santa Cruz, analyzed the Cassini probe's scans of Titan's gravity field. The strength of the gravitational pull any point on a surface exerts depends on the amount of mass underneath it. The stronger the pull, the more the mass below. Researchers then compared these gravity results with the structure of Titan's surface. They expected that regions of high elevation would have the strongest gravitational pull, since one might suppose they had extra matter underneath them. Conversely, they expected regions of low elevation would have the weakest gravitational pull.

What the investigators discovered shocked them. Contrary to expectation, the regions of high elevation on Titan had the weakest gravitational pull. At first they assumed that they were seeing the data backwards, but after they could not make that finding go away, they hit upon a model that explains these observations."

Hemingway imagined mountains on Titan having roots. "It's like how most of an iceberg actually lies submerged underwater," he said. "If that root is really big, bigger than normal, it would displace water underneath it." Now ice has a lower density than water as both ice cubes and icebergs demonstrate. These high-elevation areas on Titan apparently have roots large enough to displace a lot of water under them, meaning they exert a weaker gravitational pull.

Ice is buoyant in water. "In order to essentially hold these big icebergs down and keep them from bobbing up, that means Titan's shell has to be extremely rigid," Hemingway said. It remains uncertain what makes Titan's shell this rigid. The ice might possess cage-like molecules known as clathrates that could make it stiffer. Also, "if the ocean underneath the shell is colder than before thought, that could make the ice shell thicker and thus more rigid," Hemingway said.

This rigidity could mean Titan's shell is less geologically active than once thought. "If at least the top 40 kilometers (25 miles) is very stiff and cold and dead. To have cryovolcanoes that erupt water instead of lava on Titan's surface, you have to be more creative about how that might happen."

Their model also suggests Titan's shell has seen an extensive amount of erosion, with features carved more than 200 meters (650 feet) deep on it surface. "We now need to figure out how so much material could get broken up and transported long distances across Titan's surface," Hemingway said.

One implication relates to whether or not Titan's interior is separated into distinct layers. But maybe Titan is a mixture of ice and rock from the core nearly all the way out, and it's only in the last part near its surface that it's differentiated into ice and water. We don't know.

"What we need is a Titan Orbiter," Hemingway says. "That way we can have much better readings of Titan and learn more about its ice shell and its interior." That could be a generation away. ##

URANUS

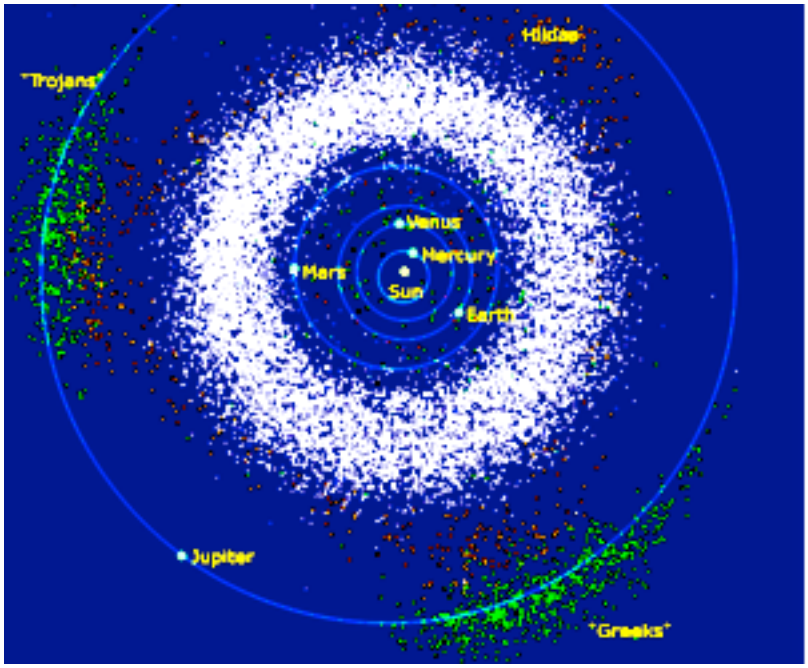
First Trojan Asteroid found in Uranus Orbit

http://www.space.com/22590-**uranus-trojan-asteroid-discovery**.html

[Editor's summary. For the full article see the link cited above]

Astronomers have discovered an unexpected, novel kind of triangle in the sky — one whose points are the sun, Uranus and the first "Trojan asteroid" ever seen near the tilted planet. The discovery of Uranus' Trojan asteroid, designated 2011 QF99 for Uranus suggests that both Uranus and Neptune could have far more such asteroid companions than previously thought, scientists say.

In astronomy-speak, objects that share their orbit with a planet — but do not collide with the world — are known as Trojans. Such objects have been seen around several planets in our solar system, including the Earth. The newfound asteroid 2011 QF99 near Uranus is the first ever seen for that planet.



This graphic shows the distribution of Jupiter's Trojans (and Greeks) centering 60° ahead of and behind Jupiter in its orbit around the Sun and spatial relation to the main Asteroid Belt between Jupiter and Mars.

Info on "Trojan Asteroids" – http://en.wikipedia.org/wiki/Trojan_(astronomy)

Info on Neptune's Trojans – http://en.wikipedia.org/wiki/Neptune_trojan

(As yet, there have been no Trojan asteroids detected in Saturn's orbit)

Info on Jupiter's Trojans – http://en.wikipedia.org/wiki/Jupiter_Trojan

Info on Earth's Trojans – http://en.wikipedia.org/wiki/Earth_trojan_asteroid

PLUTO'S MOON CHARON

Focus on Charon: a Giant Moon for the 9th Planet

http://www.spacedaily.com/reports/**A_Giant_Moon_for_the_Ninth_Planet**_999.html

[Editor's summary. For the full article e the link cited above]

July 10, 2013 - This week the New Horizons mission team is celebrating the 35th anniversary of the discovery of Pluto's largest and "first" moon, Charon. This discovery was made in 1978 by U.S. Naval Observatory astronomers James Christy and Robert Harrington, working in Flagstaff, Ariz., and Washington, D.C.

Charon, whose discovery was announced on July 7, 1978, **orbits about 19,400 km (12,500 mi) from Pluto and has a diameter of about 1,207 km (750 mi)** – about the width of Texas.

Half the diameter of Pluto, Charon is the largest moon in our solar system "relative to its planet."

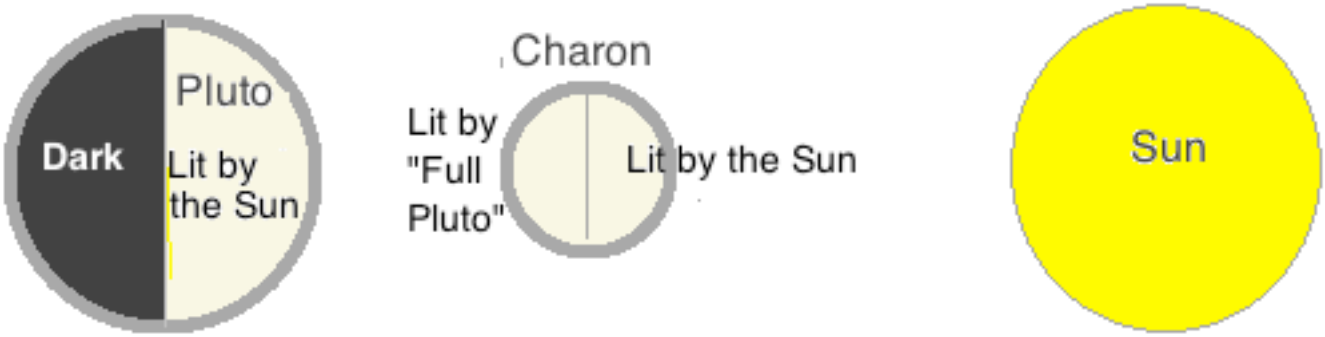
Charon's reflective but almost colorless surface is covered by water ice, and may contain traces of ammonia or ammonium as well. Its interior is much less rocky than Pluto (which is nearly 70-percent rock). By contrast, Charon's interior exhibits a nearly 50-50 combination of rock and water ice. And unlike Pluto, Charon has no substantial atmosphere.

The surprise discovery of Charon ushered in the modern understanding of Pluto as both a double planet and the product of a giant collision that formed the system in much the same way as the Earth-Moon system was formed.

We now know that Charon, is not Pluto's only moon, but orbits Pluto with at least four much smaller moons: Nix, Hydra, Kerberos and Styx. All Pluto's moons orbit in circular paths and in Pluto's equatorial plane.

Charon has bragging rights

- From Charon, Pluto looms large in the sky-more than 14 times as wide and 200 times as big of an area as the Earth's moon appears in our sky. A sight to behold and never forget!
- At "full Pluto," Charon's night side is about 50-percent brighter than a full moon in Earth's nighttime sky. which means that at that time Charon is lit 100%, by a full Pluto on one side, and by the Sun on the other side - see sketch below - this lineup happens every



Relative sizes of Pluto and Charon (but not the distance between them) to scale. Graphic by Editor.

Average **distance between Charon** and **Pluto**: 19,570 km (12,160 mi) (c.1/20th Earth-Moon distance)

Charon will appear some 7 times bigger than the Moon does to us.

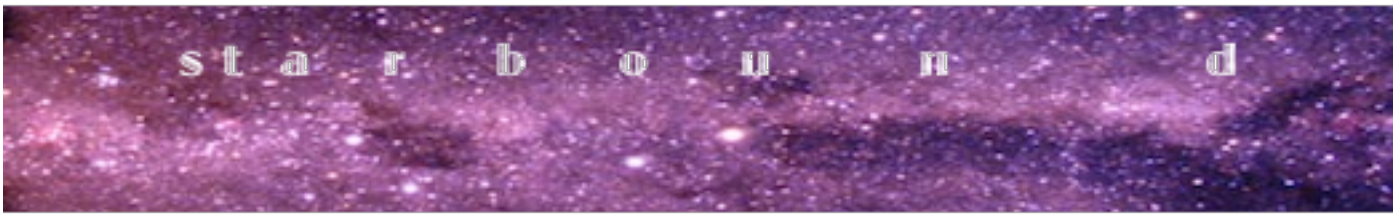
Distances and size of Sun not to scale. This line up with the sun happens every 6 and a half days.

Pluto and Charon always keep the same face towards each other, meaning that in theory, you could build a "ladder/tube" between them for transportation of goods and people back and forth. That vertical bridge would have to be elastic to accommodate slight eccentricity in Charon's and Pluto's orbits around their common barrycenter (center of gravity and/or mass)

The good news: The **New Horizons** spaccraft is on course to fly by and make the first reconnaissance of the Pluto system in less than two years from now, in July 2015.

When it does, **the spacecraft will turn these moons and their parent planet Pluto from points of light into well-mapped worlds, chart their compositions in exquisite detail, explore Pluto's atmosphere, search for other moons and rings,** and make many other observations as well.

The bad news, is that tNew Horizons is just a flyby mission, so not all of Pluto or Charon will be photographed and mapped, and all the desired photos and information has to be grabbed in a few hours. But as a teaser, we can expect this to be a good one. To date, every planetary probe has produced surprising and unsuspected information and intriguing photos. ##



STARBOUND TELESCOPES

Kepler Space Telescope Unlikely To Make Full Recovery

http://www.huffingtonpost.com/2013/07/25/kepler-space-telescope-nasa_n_3653455.html

[Editor's summary. For the full article see the link cited above]

July 25, 2013 - NASA's Kepler spacecraft probably won't bounce back completely from the malfunction that stalled its planet-hunting efforts two months ago, mission officials say. (Several recent attempts to "bypass" the problem have failed, and NASA has exhausted its options.

The telescope was hobbled in May when the second of its four orientation-maintaining reaction wheels failed, robbing the instrument of its precision pointing ability. Engineers managed to get the balky wheels turning again recently, but both devices are far from healthy, showing much higher levels of friction than they once did. So the odds that Kepler will return to business as usual are minute.

http://www.space.com/21172-greatest-alien-planet-discoveries-nasa-kepler.html

NASA had hoped it could find a new assignment for Kepler, but has now given up on that option.

Spinning Kepler's wheels

launched in March 2009, kicking off a 3.5-year prime mission to determine how common Earth-like planets are throughout the Milky Way galaxy.

Designed to observe 150,000 stars simultaneously, Kepler looked for the telltale brightness dips caused when planets pass in front of, or transit, the faces of these stars. Kepler needs three functioning gyroscope-like reaction wheels to perform this precision work. It launched with four — three for immediate use and one set aside as a spare. But one wheel, known as #2two, failed in July 2012. Then another (#4) gave up the ghost on May 11 of this year, putting a halt to exo-plant searching.

.On the plus side

The $600 million Kepler mission has revolutionized the search for exo-planets , spotting 3,277 candidates to date. Just 135 have been confirmed so far by follow-up observations, but mission scientists expect that more than 90 percent will end up being the real deal. Kepler may still be able to gather valuable exoplanet data. For example, as it will probably still be capable of precision pointing for short periods of time, even in its current condition. But "planet hunting per se is off the table."

We had hoped for much more, but Kepler has revolutionized our expectations on the commonality of planetary systems in our part of the galaxy, and by extension, in the universe as a whole. Tree cheers!

SEARCH FOR EXO-PLANETS & LIFE

The Milky Way Galaxy may be home to 17 Billion "Earths"

http://www.space.com/19160-**alien-earth-size-planets-population-infographic**.html

[Editor's summary. For the full article see the link cited above]

Judging from the early surveys of the Kepler Space Telescope, which has found over 2,500 extra-solar planetary systems (stars with children), large gas giant planets the size of Neptune or Jupiter are much less common than worlds the size of Earth. The study finds that 17 percent of all stars probably have an exo-Earth (a planet 0.8 to 1.25 times the size of Earth) in an orbit of 85 or less Earth days, in most cases too close to its sun to make a comfortable home for life "as we know it."

About one in four stars have a super-Earth (1.25-2 times the mass of Earth) in an orbit of 150 days or less. The same number of stars have a mini-Neptune (2-4 times the size of Earth in an orbit of 250 days or less.

Larger planets are much rarer. Three percent of stars have a large Neptune (4 to 6 times the size of Earth) and 5 percent have a gas giant (6-22 times the size of Earth) in an orbit of 400 days or less."

For more, go to the link above. We have sampled only one tiny area of the sky.

SETI Evolution: Searching for Aliens Using Whale Songs and Radios

http://www.space.com/21827-**seti-extraterrestrial-intelligence-search-evolution**.html
http://www.technewsdaily.com/2535-**top-space-alien-communications**.html

[Editor's summary. For the full articles see the links cited above]

LEFT: A photo of the Allen Telescope Array taken by SETI astronomer Seth Shostak. The SETI (Search for Extraterrestrial Intelligence) Institute uses this radio dish array in Northern California to search for signals from civilizations beyond the solar system. **RIGHT:** artwork showing popular image of Aliens with UFO

The Search for Extraterrestrial Intelligence can be traced back 1896 with the suggestion by Nikola Tesla that radio transmissions could be used to contact extraterrestrial intelligent beings. In 1899, Tesla actually did detect signals incompatible with terrestrial electric storms — but he might have been picking up "storms" on Jupiter whose plasma torus emits strong radio flux, making Jupiter a kind of miniature pulsar.

In August 1924, Mars was closer to Earth than it had been in over a century. So the U.S. Naval Observatory imposed radio quiet for five minutes out of every hour at so that a dirigible equipped with a radio receiver could listen for any Martian signals.

In 1959 Philip Morrison and Giuseppe Cocconi pointed out that intelligent signals might be detected using radio antennas. Independently, in 1960, Frank Drake used a radio telescope to conduct the first SETI project, targeting two nearby sun-like stars, Tau Ceti and Epsilon Eridani, searching for signals using the electromagnetic frequency of 1.420 gigahertz with a 400 kilohertz bandpass: about 400,000 different SETI channels fit in a region of the spectrum this wide, known as the "water hole," a range of frequencies in which water vapor does not absorb very well (and so a water-based planet might transmit into space at such frequencies).

Drake developed a way of organizing the search for extraterrestrials using a tool now known as the "Drake Equation." The equation reads $N = R^* f_p n_e f_l f_i f_c L$, where n is the number of interstellar communicating civilizations, and the other terms have the following meanings:(for an explanation of that formula, see the article referenced above.)

To study exobiology, we have been exploring the extremes of biology on Earth (e.g., the NASA astrobiology program). Investigators have focused on the dry valleys of Antarctica or the deserts of the Mohave in California, or of the Atacama in Chile.

We can also research how other creatures on Earth communicate with one another. Fore example, humpback whales are also a socially complex species, and in part because they rely — as the dolphins do — on vocal communication more than gestural or facial expressions. This species also had a global communication system millions of years before humans did. These animals also resembled humans in they way they dealt with noise.

In addition to radio searches, optical SETI is now becoming more widespread. Radio SETI is looking for narrow-band transmissions (where one can turn the dial of the radio once and be on a new station), which nature apparently cannot produce. Optical SETI, however, relies on the detection of nanosecond pulses of light. Again, technology can produce such signals, but, as far as scientists know, nature cannot (the quickest pulses in nature may be millisecond pulsars).

[Editor: for much more detail, read the linked article above.] ##

New Model Could Help Identify Potentially Habitable Alien Planets

September 10, 2013 - http://www.space.com/22737-**super-earth-atmospheres-computer-model**.html

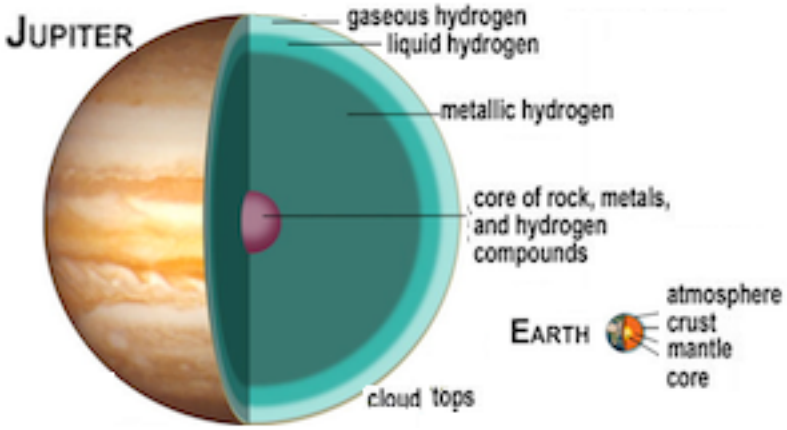
[Editor's summary. For the full article, see the link cited above]

In just the past year, a trio of super-Earths found in the habitable zone of the star Gliese 667C, and two probably rocky planets in the Goldilocks zone (where temperature highs and lows allow liquid water on a planet's surface) around Kepler-62, and possible super-Earths orbiting Tau Ceti and HD 40307 at just the right distance for liquid water to exist on their surfaces, "under certain conditions."

The hunt is on for an "Earth-2" "where life as we know it could possibly exist. We haven't found one as yet. We cannot yet determine whether a planet is hospitable to life, but David Kipping of the Harvard-Smithsonian Center for Astrophysics and his team of astronomers have developed a new theoretical model that can tell us with one swift glance whether a super-Earth — a world with two to 10 times the mass of our planet and up to twice the diameter — has an atmosphere that might, or might not, be suitable for life. It's all about whether a planet has an atmosphere and how that atmosphere is connected to the relationship between a planet's mass and diameter.

Astronomers have been using two main exoplanet detecting techniques that are beautifully complementary. When a planet passes in front of its star, blocking a fraction of the starlight — we can determine the diameter of the planet from the size of the transit. That planet also exerts a gravitational tug on its parent star. If we can detect that tug we can calculate the planet's mass.

Very few planets orbit their star at an appropriate angle for us to see a transit. And some exoplanets and their stars are too distant and faint for us to accurately measure their "radial velocity" tug. Many of the Kepler telescope's candidate planets fall into this category. But for those worlds for which we can determine both size and mass, we can divide the mass by the calculated volume to determine the planet's density, telling us whether it is likely rocky, gaseous or icy.



Jupiter and Earth are shown above in true relative sizes

The computer model that Kipping has developed, along with Harvard's Dimitar Sasselov and Princeton's David Spiegel, allows an astronomer to plug in these numbers for mass and radius and, with the knowledge of the density, figure out whether a super-Earth has a light but extended atmosphere or a relatively thin, heavy atmosphere.

Earth's atmosphere is the latter kind — a 100 km (62 mi) layer of nitrogen, oxygen, carbon dioxide, argon, water vapor and neon that contributes just 1.5 percent of Earth's radius.

We don't know if an extended atmosphere of mostly hydrogen and helium — similar to Uranus' or Neptune's atmospheres but warmer — could support life, and so searches for Earth's twin may want to eliminate such worlds from the list of potential candidates.

Editor's comment:

It was not that long ago, when it was impossible to determine if any given star had planets. But the quest to develop planet-finding techniques had been on for several decades before the first "find."

And who is really interested in "super-Earths" anyway. How about looking for "sister Earths" - worlds not only at the right distance from their sun, but of a comparable mass and size?

And how about developing methods to detect surface oceans? Better yet, a world with both ocean and land areas? And how about looking for Nitrogen/Oxygen atmospheres? Not to forget a system's age: It took Earth 4 billion years to develop metazoan (multicellular) life. So a host star's age is important also.

It seems a bit premature to celebrate and party. But we _are_ making progress. ##

The Fascinating Case of Zeta Reticuli 1 and 2

http://en.wikipedia.org/wiki/Zeta_Reticuli

Report and Speculation by Peter Kokh

How close are truly "sun-like" stars likely to be? In our immediate neighborhood within 5 parsecs (16.3 Light Years) of Earth, per a study the editor did c. 1960 (if not earlier) we calculated that the "average closest neighbor" is 6+ LY away and neither of the neighboring pair is guaranteed to be sunlike

Humankind, around our as yet unnamed "The Sun," would seem to be especially blessed to have a sun-like binary only 4.3 light years away, Alpha Centauri A and B with a third smaller star, Proxima Centauri orbiting the pair from some distance. You might say we won "a" prize in the interstellar lottery!

But not much further off are two sun-like single stars only a fraction of one light year apart Zeta¹ and Zeta² Reticuli – 39.2 LY away (12 parsecs) – 62°34'31" south (cannot be seen from most of the US of Europe) is a very widely separated double star system in the southern constellation of Reticulum.From the southern hemisphere the pair can be seen in very dark skies as a naked eye double star. Zeta² Reticuli is orbited by a circumstellar debris disk. Both stars are solar types, G2 and G1, that share similar characteristics with the Sun. They belong to the Zeta Herculis Moving Group of stars with a common origin.

Both stars share the same motion through space, confirming that they are gravitationally bound and form a wide binary star system. They have an angular separation of 309.2 arc second (5.2 arc minutes) far enough apart to appear as a close pair of separate stars to the naked eye. Estimated of their ages vary greatly, from 1.5 – 8 billion years (Sun is 4.6 by.)

The actual distance between the two stars, Zeta 1 and Zeta2 is at least **3,750 AU** (1 AU is the average distance between Earth and the Sun), **or 21.7 light days**. In comparison, the Sun is 1570 light days from Alpha Centauri system, some 173 times as great a separation, Now if life arose on planets around each, ZR1 and ZR2, and civilizations arose on both in a roughly contemporary time, the incentive for star travel from one to the other would be far far stronger than it is for us here on Earth. Zeta 1 But that is a lot of "ifs." But I know of no more favorable situation.

Both stars share similar physical characteristics to the Sun, and are considered "solar analogs." Zeta¹ has 96% of the Sun's mass and 84% of the diameter. Zeta² is slightly larger and more luminous than Zeta¹, with 99% of the Sun's mass and 88% of the Sun's radius. Both stars are somewhat deficient in "metals" having only 60% of the proportion of elements other than hydrogen and helium as compared to the Sun. As we've noted elsewhere that could be compared to an inner system akin to Mercury-Earth-Mars, i.e. minus a Venus. Sixty percent of the metal elements is still plenty to work with, however discouraging it is to some "experts" who clearly haven't done the math.

In contrast, Proxima Centauri is c. 87 light days from Alpha Cent AB or a bit over 4 times as far separated as Zeta Reticuli 1 and 2 – So even the Alpha-Proxima separation is greater than Zeta 1-2!

How bright are the Zeta pair to one another? Let's see which reader can figure that out first! It will be far brighter than Sirius, the brightest star in our own heavens. Even before inhabitants of a world around one figured out how close other was, its brightness would have dominated their lore from time immemorial

What if one system had an "inhabited' planet? Its inhabitants would soon have discovered that they rotate around a common center of gravity every 170,000 years or so, thus they are not just systems "passing in the night." More likely than not life-rich planets around each would not be at the same stage at the same time. One would mature first, and find the other to be in a "prehistoric" situation.

If inhabitants in one system discovered a similar planet orbiting the other, the incentive to develop "inter-solar" flight to reach the other would be enormous. 21.7 light days would require an average speed of 1/100th the speed of light (300 km/s) to reach in 2170 days (5.9 years) – quite a decent speed by our current abilities – but they would have an enormously greater incentive to develop "sub-light speed" technology than we have.

This unique nearby pairing has not gone unnoticed. Indeed, a "cult" has grown up among those who believe Earth has already been visited by "aliens" around this very star system, due to this advantage!

Read up on this for fun, but don't take any of it seriously!

http://en.wikipedia.org/wiki/Stars_and_planetary_systems_in_fiction#**Zeta_Reticuli**

http://www.ufoconspiracy.com/reports/**zetareticuli_star_sys**.htm

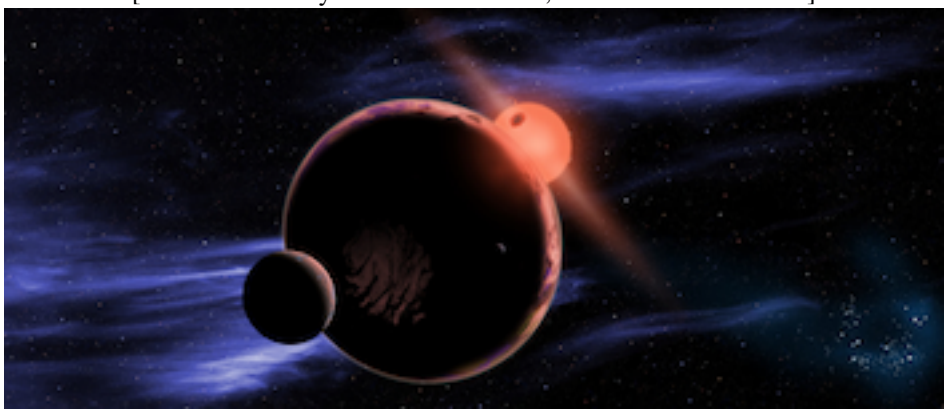
http://nexusilluminati.blogspot.com/2012/02/**visitors-from-zeta-reticuli-star-system**.html

http://en.wikipedia.org/wiki/Betty_and_Barney_Hill_abduction ##

The Drake Equation Revisited: Interview with Planet Hunter Sara Seager

http://www.space.com/22648-**drake-equation-alien-life-seager**.html

[Editor's summary. For the full article, see the link cited above]



This artist's (David A. Aguilar) conception shows a hypothetical habitable planet with two moons orbiting a red dwarf star. Astronomers have found that 6% of all red dwarf stars have an Earth-sized planet in the habitable zone, which is warm enough for liquid water on the planet's surface.

Editor's comment: What some forget, is that to be warm enough, the planet must be so close to its red dwarf sun that its tidal forces will force the planet's rotation to match its orbital period (~year) so that one side always faces its sun and is too hot, the other side frozen. Further, red dwarf stars are also "Flare Stars" so any planets will be frequently blasted by massive coronal ejections so as to be totally uninhabitable, while the far side of the planet is deep frozen.

Planet hunters keep finding distant worlds that bear a "resemblance" to Earth. Some of the thousands of exoplanet candidates discovered to date have similar sizes or temperatures. Others possess rocky surfaces and support atmospheres. But no world has yet provided an unambiguous sign of the characteristic that still sets our pale blue dot apart: the presence of life.

That may be about to change, says exoplanet expert Sara Seager of MIT. Upcoming NASA missions such as the **Transiting Exoplanet Satellite Survey (TESS)** and the **James Webb Space Telescope (JWST)**, both due to launch around 2018, should be able to find and characterize Earth-Like planets orbiting small stars. We may be able to detect and characterize the atmospheres of some of these planets.

In 1961, astronomer Frank Drake developed an equation that summarizes the main factors to consider in the question of radio-communicative alien life, includging the number of stars in our galaxy with planets and the length of time advanced alien civilizations might releaseradio signals into space.

Instead of aliens with radio technology, Seager has revised the Drake equation to focus on simply the presence of any alien life. Her equation can be used to estimate how many planets with detectable signs of life might be discovered in the coming years. The Seager equation looks like this:

$N = N_* F_Q F_{HZ} F_O F_L F_S$

N = the number of planets with detectable signs of life

N_* = the number of stars observed

F_Q = the fraction of stars that are quiet

F_{HZ} = the fraction of stars with rocky planets in the habitable zone

F_O = the fraction of those planets that can be observed

F_L = the fraction that have life

F_S = the fraction on which life produces a detectable signature gas

Focusing on M stars, the most common stars in our neighborhood that are smaller and less luminous than the sun, Seager plugged in values for each term. Her calculation suggested that two inhabited planets could reasonably turn up during the next decade.

Editor: Interesting, but as we pointed out, Seager is missing something lethal about Red Dwarfs.

Read these relevant articles by the editor:

MMM #36 **Hydro-tectonic planets**: What is an "Earthlike Planet?"

MMM #38 **Of Tides and Stars**

MMM #40 **Brown Dwarfs**

MMM #45 **Welcome-Mat Worlds**

All in the MMM **Starbound Theme Issue**, http://www.moonsociety.org/publications/mmm_themes/mmmt_starbound.pdf

Voyager 1's historic Journey Into Interstellar Space Beyond the Solar Bubble

www.huffingtonpost.com/2013/09/12/**nasa-voyager-1-space-probe-solar-system**_n_3915762.html
http://www.nasa.gov/mission_pages/**voyager**/voyager20130912.html
www.space.com/22752-voyager-1-goes-**interstellar-solar-system-boundary-passed-video**.html
[Editor's summary. For the full articles, see the links cited above]

NASA's Voyager 1 spacecraft officially is the first human-made object to venture into interstellar space. The 36-year-old probe is about 19 billion km (12 billion mi) from the Sun.

Editor's reality check: =17.9 light hours - yes, not even one light day out from Earth!
Put another way, Voyager 1 is now **6.8 x as far from the Sun as Neptune**.

The above graphic shows relative distances, but not direction - Ed.
Alpha Centauri's distance is 4.3 light years = 1571 light days = A humble step!
http://www.space.com/22783-voyager-1-interstellar-space-star-flyby.html
"In 40,000 years," the probe may reach a star called AC +79 3888, some 17.6 light-years from Earth.

New and unexpected data indicate Voyager 1 has been traveling for about one year through plasma, or ionized gas, present in the space between stars. Voyager is in a transitional region immediately outside the solar bubble, where some effects from our sun are still evident.

"Now that we have new, key data, we believe this is mankind's historic leap into interstellar space," said Ed Stone, Voyager project scientist based at the California Institute of Technology, Pasadena. "The Voyager team needed time to analyze those observations and make sense of them. But we can now answer the question we've all been asking -- 'Are we there yet?' Yes, we are."...

Voyager 1 does not have a working plasma sensor, so scientists needed a different way to measure the spacecraft's plasma environment to make a definitive determination of its location. A coronal mass ejection, or a massive burst of solar wind and magnetic fields, that erupted from the sun in March 2012 provided scientists the data they needed. When this unexpected gift from the sun eventually arrived at Voyager 1's location 13 months later, in April 2013, the plasma around the spacecraft began to vibrate like a violin string. On April 9, Voyager 1's plasma wave instrument detected the movement. The pitch of the oscillations helped scientists determine the density of the plasma. The particular oscillations meant the spacecraft was bathed in plasma more than 40 times denser than what they had encountered in the outer layer of the heliosphere. Density of this sort is to be expected in interstellar space.

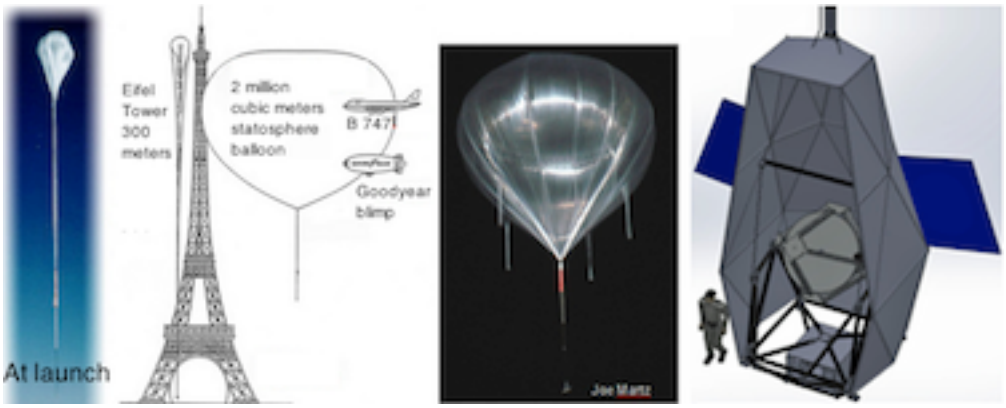
The plasma wave science team reviewed its data and found an earlier, fainter set of oscillations in October and November 2012. Through extrapolation of measured plasma densities from both events, **the team determined Voyager 1 first entered interstellar space in August 2012.**

Voyager 1 and its twin, Voyager 2, were launched 16 days apart in 1977. Both spacecraft flew by Jupiter and Saturn. Voyager 2 also flew by Uranus and Neptune. Voyager 2, launched before Voyager 1, is the longest continuously operated spacecraft. It is about 15 billion kilometers (9.5 billion miles) away from the Sun. ##

Exoplanet-Hunting Telescope to Seek Invisible Worlds from Giant Balloon

September 23, 2013 – http://www.space.com/22914-**echobeach-balloon-exoplanets**.html

[Editor's summary. For the full articles, see the links cited above]



Left 3 images: EchoBeach balloon concept – **Right:** CAD model of the Echobeach balloon experiment.

"**EchoBeach**" is a plan to send a giant helium balloon into the skies to study planets in other solar systems. It would be **a beachhead for Echo** – a more ambitious space mission currently under consideration. The EchoBeach experiment would reveal **what the atmospheres of distant alien worlds are made of** – and do so much more cheaply than other space missions. A 1.5m telescope would hang from a balloon at very high altitude – 40 km (or nearly 25 mi) – in the stratosphere and able to do some very compelling science." Echo will be much, much better. It will be in space, which means the Earth's atmosphere won't pollute the observation, and therefore it will be of orders of magnitude more sensitive that anything we have used so far, including EchoBeach.

EchoBeach vs. Echo

EchoBeach could be launched as early as 2017 and would be a pathfinder for a space mission dubbed Echo, which, if it gets the go-ahead, will also be studying the chemical composition of the atmosphere of exoplanets – but on a much wider scale. The catch is that Echo is one of five proposed space missions the European Space Agency. The verdict on which mission gets the go-ahead should come in February 2014. While Echo will be able to study hundreds of exoplanets, including those in what is called the "habitable zone" where water could be found in liquid form, EchoBeach will only be sensitive enough to look at the hottest and largest of them, the Jupiter-like gas giants.

Echo would only be launched in 2022 at the earliest, and the balloon-borne precursor would get there first. While we are waiting for Echo to give us the ultimate view of all these alien worlds, EchoBeach could help as a forerunner, an aide for Echo, helping us to design the best possible space mission

Both projects will be using a method called transiting spectroscopy. The transit method of spotting an exoplanet is indirect, and it is the one that was used by the Kepler telescope. The instruments measure tiny dips in the brightness of stars when a planet passes through the line of sight.

Echo vs. Kepler

The now retired space observatory Kepler has found thousands of potential exoplanets in recent years; Hubble has also spotted a few, as have several big ground-based telescopes. But so far, scientists have only been able to characterize the atmosphere of eight of them. But that's because exoplanets are too far away, faint and close to their parent stars to be imaged directly.

After a planet is confirmed, we want to determine its key parameters, mass and radius. Other instruments then measure **whether there is an atmosphere, and if so, what it is made of**. for this purpose, both EchoBeach and later Echo could have a spectrometer, which disperses light into its different colors, like a prism. Significantly, **both EchoBeach and Echo will be working in the infrared part of the spectrum, invisible to the naked eye.**

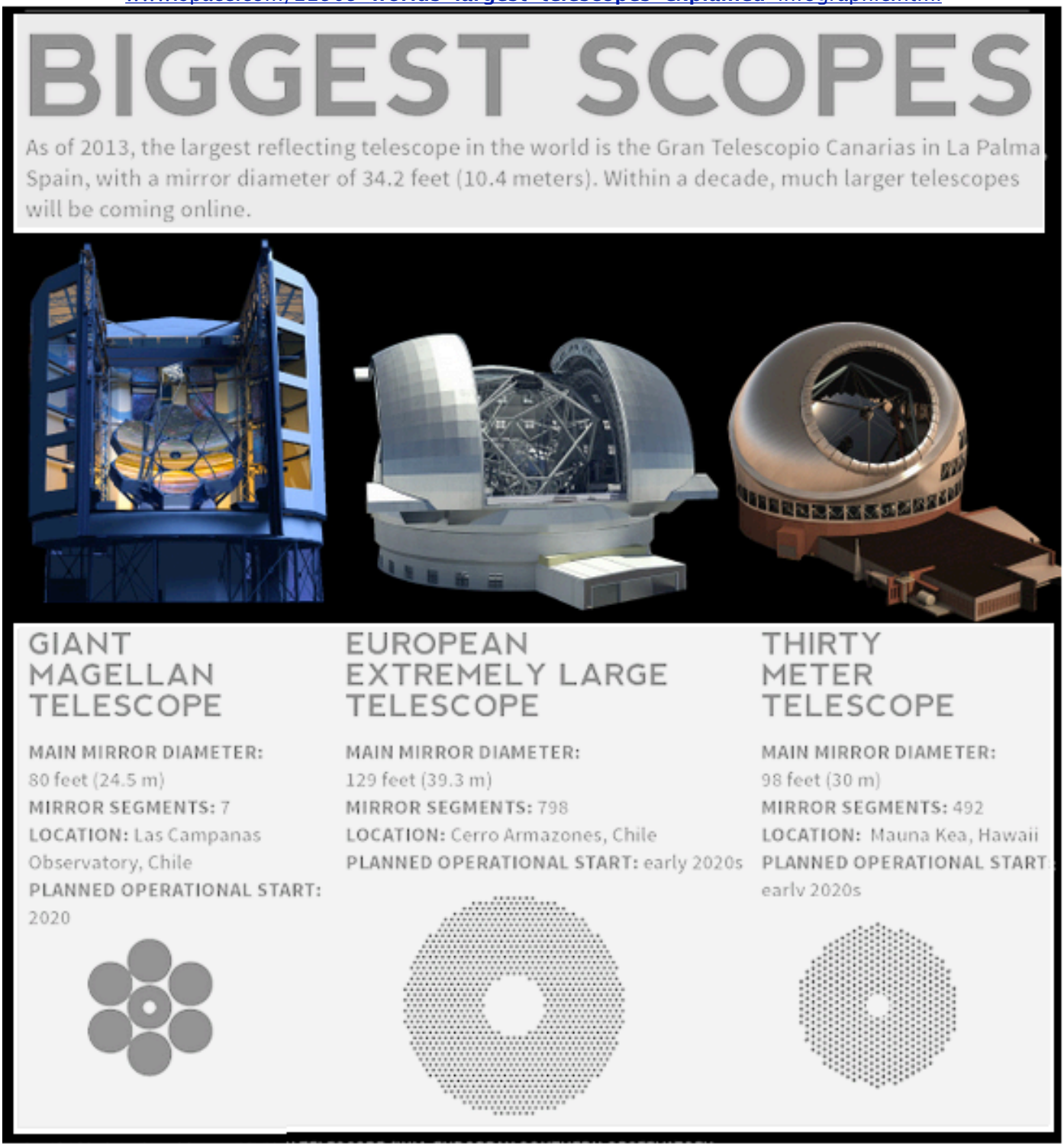
Balloon-borne missions

A balloon can carry a telescope above 99.5 percent of the atmosphere and provide a near-space environment. The EchoBeach balloon has had forerunners. A balloon called BLAST carried an instrument tasked with studying star formation, and preceded a similar instrument on the ESA Herschel telescope, three years before Herschel went into orbit. Another balloon program, Boomerang, was a precursor for an instrument on the ESA-led Planck mission, which peers deep into the early cosmos, studying the Big Bang's fossil light – the cosmic microwave background radiation. And **balloons cost much less, which makes sense for testing new technologies**. ##

World's Largest Reflecting Telescopes Explained (Infographic)

By Karl Tate, Infographics Artist | August 30, 2013

www.space.com/22505-**worlds-largest-telescopes-explained**-infographic.html



We inverted the colors of the text areas to make this graphic easier on the eye.
To view the original, go to the link above.

http://www.space.com/19098-**alma-telescope-array-photos**.html
http://i.space.com/images/i/000/011/250/i02/**alma-antenna-snow-mountain-road**.jpg?1311887740
http://i.space.com/images/i/000/009/805/i02/**7-meter-antenna-atacama-eso**.jpg?1306247779
http://i.space.com/images/i/000/012/464/i02/**alma-telescope-array-chile**.jpg?1317481288
http://i.space.com/images/i/000/017/963/i02/**milky-way-alma**-1000.jpg?1338410994

Messier Object Sky Wonders – Messier 31 "Andromeda"

By Aleksandra Voinea

Messier 31 is our largest neighbor galaxy, the Andromeda Galaxy. Together with M32 and M110, dwarf elliptical galaxies, Messier 31 forms the Local Group of Galaxies.

Visible to the naked eye, Andromeda Galaxy was initially mistaken for a nebula. It was William Huggins, pioneer of spectroscopy, who, in 1864 noted the difference between the average gaseous nebula (and their line spectra) and galaxies with star-like, continuous spectra. He found that M31 had a continuous spectrum.

Andromeda is most interesting due to the unique relationship with its companion, M32, which is responsible for a great amount of structural disturbance inside M31. Consequently, M32 also lost many stars to M31.

The brightest globular cluster in Andromeda Galaxy is G1, who also occupies the title of the most luminous globular cluster in the Local Group of Galaxies, outshining Omega Centauri (brightest cluster in the Milky Way).

Very prominent in northern skies and visible to the naked eye as a faint patch of light to those living far from city lights, it is the nearest spiral galaxy to our own Milky Way. Besides being the only galaxy visible to the naked eye, it is also the most distant object that is ever visible to the naked eye.

Our own galaxy, known as "The Milky Way," seen at a similar angle, must look similar, but a bit smaller. M31 and the Milky Way are drifting towards one another and may collide in about 4 billion years.

For more on M31 see the following:

http://en.wikipedia.org/wiki/Andromeda_Galaxy

http://www.space.com/21854-andromeda-galaxy-m31-photos-gallery.html

http://www.space.com/15590-andromeda-galaxy-m31.html

http://www.space.com/22177-andromeda-galaxy-photo-hsc.html ((highest resolution photo yet of M31)

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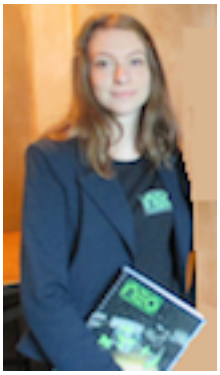

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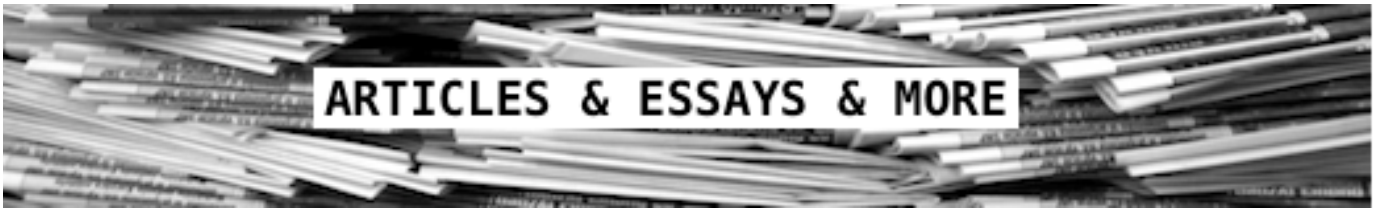


Covering Up Lunar Habitats with Moondust? – Some Precedents Here on Earth

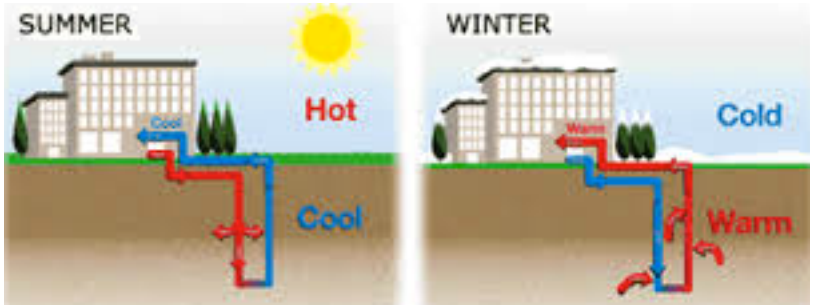
By Peter Kokh

On Earth, we don't have to shield our homes and living and working structures with a blanket of "Earth dust" to protect ourselves from cosmic rays. Earth's Van Allen belt "blanket" takes care of that need for us. And for moderating heat and cold the Moon experiences, our atmosphere blanket takes care of that, if our Nitrogen and Oxygen atmosphere ever got cold enough, it would freeze out to a 4.5–5 meters (15–16 ft) of Nitrogen and Oxygen Snow. The need to be met is quite similar.

Shielding is needed on the Moon also to moderate thermal extremes of cold and heat as well as protection from cosmic rays. As such, moondust is very good "insulation." And at least in temperate and subpolar areas, we need a blanket of insulation for this use. Note that despite the wide temperature swing on the lunar surface, 2 meters (6 ft) down, the temperature is constant, at the equator a comfortable 23° C.; at 60° latitude N or S, that drops to -24°C 9–11°F) which is manageable..

About Five meters of moon dust will not only provide long term protection from cosmic rays, it will allow the use of "geothermal" heating and cooling systems that save excess dayspan heat for nightspan heating, excess nightspan cold for dayspan heating. Dayspans and Nightspans are 14.65 days long each.

If you are not familiar with geothermal heating and cooling systems, do a **Google/Bing Image search** for "**geothermal heating and cooling systems**" to see illustrations of how these systems work.



The balance on the Moon is much more favorable than on Mars, where "the hot" season is only "cool" and the cold season is "very cold," plus the seasons are a 26 times longer than the lunar dayspan-nightspan cycle. In this respect, there are many examples of shielding "insulation" on our home world that address this need to moderate seasonal cold in the arctic and both heat and cold in temperate zones..

- **Igloos, made of blocks of compressed snow**
- **Sod-covered houses**
- **Homes carved into rock**
- **"Earth-sheltered"** and **"Hobbit"** Homes
- **Bermed buildings** that insulate the lower parts of a building

Above: Igloo Homes, and a hotel, in Arctic North America built with compressed snow blocks


Above: Homes carved out of desert rock, soil – Coober Pedy, Australia and Cappadocia, Turkey



Above: Grassland Homes in tree less areas covered with insulating sod. One in Africa with sand bags


Left: A t**raditional Earth-sheltered home** with exposed south facing window wall
Right: The unique "**Terra Lux**" home with periscopic picture windows and solar domes


"**Hobbit"** inspired homes come in amazing varieties.


Bermed buildings: in these two, only the walls below window level are soil-insulated

Heaping up Moon Dust over living spaces isn't such an "alien" idea after all! (But if it were more common, then we'd be cheated out of the thrill of paying high heating and cooling costs!)

No, **we can't adorn this moondust covering with living plants.** But we can adorn lunar exteriors all the same, using materials available or producible on the Moon.

See "**Moon Roofs**" – MMM #55.

See **"Taking Back the Surface: Above Surface Architectures for Moon & Mars Habitats"** – MMM #137

Both articles are republished in the **MMM Lunar Construction Theme issue**: (free download)

http://www.moonsociety.org/publications/mmm_themes/mmmt_construction.pdf ##

How can we Stimulate Greater Use of the International Space Station?

By Peter Kokh

"Stimulating Greater Use of the ISS" is the title of a recent article by Jeff Foust in Space Review. Here the short introductory blurb reads: "As researchers meet this week to discuss research on the International Space Station, NASA and the organization that manages ISS research are being pressed to make greater use of the station's facilities. Jeff Foust reviews those challenges and the efforts of one startup company that believes its research could have a significant commercial payoff.

http://www.thespacereview.com/article/2328/1

This is a very important issue. NASA had wanted to cease support for ISS and "deorbit" it as early as 2016. However the International Parters protested loudly, and now the Station will remain in orbit and continue to be staffed until some time in 2020. For NASA, this is a budget question as well as a focus question. The agency has many other goals in space: the Moon, Mars, Asteroids and other interplanetary missions as well as astronomical projects.

But the Station is the far and away the most concrete evidence of human presence in space beyond our atmosphere. It is a source of inspiration to students and young people world wide. It makes us aware of out planet a one shared world whose future is in doubt as human presence on our planet has extended to a point where many ecosystems, those still surviving and holding on, are in danger.

Here are some suggestions we have thought of that would allow us ti keep the station in orbit, and indeed to grow it into something ever larger, and more productive scientifically.

Basic starter ideas

- An architectural plan for orderly expansion of existing architecture, and beyond
- A plan to put it into a higher orbit, as a compromise between more expensive access, and less expense and much lower frequency of "reboosting."
- A plan to find new partners, national or corporate, for national portions of thnne station that the owner wishes to sell or transfer
- A plan for more affordable access (commercial)
- A plan for more affordable additions
- A plan for expansion of research directions
- Partnering with research facilities on Earth

Capacity for a larger crew

- Inflatable modules: cheaper with more volume for living and for activities of any kind
- More recreational and meeting space: an inflatable gym, a conference room
- Inflatable Sky Motel for vetted VIP Visitors, and for critical negotiations (can't leave until a settlement is reached. The view of Earth below will promote "internationally" acceptable solutions.

Expansion of special Experiment Areas/modules

- A dedicated "food growth chamber like the one built by CEAC (Controlled Environment Agricultural Center) for the Amundsen-Scott South Pole Station.
  http://www.ferrarochoi.com/casestudies/southpole/southpole6_foodgrowth.html

Variable artificial g facility dorm and research pods testing moon and mars gravities in sequence

- A "dumbbell" type rotating annex, with a larger-heavier module closer to the hub rotationally balanced with a smaller-lighter one further from the hub to provide lunar 1/6th G at one end, and Mars 3/8ths G at the other – for long term experiments to determine how these gravity levels affect astronaut physical status in comparison with Zero G (or microgravity) of ISS proper
- More biospheric research on plant growth at these gravity levels

Expansion of ISS Partners List & Extending ISS Commitment through 2028 at least

- If an ISS partner wants out, its facilities should go up for sale to other existing partners, new national partners, commercial firms. Holder can refuse "insufficient" offers for up to one year.

http://spaceports.blogspot.com/2012/03/international-space-station-partners.html (Brazil?, India? South Korea? China nixed by NASA) ##

AS THE WORLD EXPANDS The Epic of Human Expansion Continues

By Peter Kokh [Previously Published in Moon Miners' Manifesto #211, December 2007]
[Republished to complement the news story above in this issue of more evidence that Life started on Mars]

I have often heard the complaining question, "Why can't we just stick to our homeworld," to which I am quick to reply, "It's too late for that. Our homeworld was Africa and we expanded beyond that nearly a hundred thousand years ago. Expanding our "world" defines that Epic. Who are we to be the generation that says "Halt!" ? This sort of impatience with "endless progress" is hardly new. In the aftermath of World War I, leading up to World War II, the great pioneering British science fiction film "Things to Come" (Raymond Massey), a film rendering of H.G. Wells' "The Shape of Things to Come" (1933) dealt with this impatience with endless change.

The irritating fact is that the pace of change, of progress, of expansion is ever accelerating, and adjusting to that is hard for many individuals. It is more than four centuries since the "world" as known to Europeans grew by the "discoveries" of the Americas. In actuality the epic of expansion has always proceeded quite a bit in advance of popular awareness of it. Humans advanced "out of Africa" into Eurasia yet few people either in Africa or Eurasia may have been aware of the new larger combined "world."

What is a/the "World?"

Perhaps most people will understand "world" to mean "the planet Earth." We speak of other planets as other worlds. That is the contemporary understanding. But to get at the real meaning of "world" we must look at the concept phenomenologically. I would define world as **"a continuum of horizons, from no point within which, the whole is visible."** That fits the "world" of our most ancient ancestors, as well as of our own era.

Originally, the "World" of humanity was Africa

While the exact figures may change as we learn more, the DNA evidence from mitochondria which are only passed on through mothers (as mitochondria are only found in the egg) is that all extant (living surviving) humans are descended from one female in Africa about 80-140,000 years ago. The date is unimportant. This does not say that there were no other proto-humans at that time, but only that, if there were, none of their descendants have survived. Nor does it say that this female mated with only one male.

The evidence goes on to conclude that all extant branches of humanity are descended from one female who made the crossing into Asia, not via Egypt, as previously thought, but across the straights of Aden at the bottom of the Red Sea, straights which these days are 20 miles across. At that time, many millennia ago, the "world" of humans began to expand considerably until all parts of Eurasia were inhabited, and migration into Australia and the Pacific Islands and even into the Americas had begun.

The World is Flat

But until we began to reach the "East" by going "West" the common perception was that the world was flat. True, ancient Greeks had realized that the world was round from two lines of evidence:

- The curvature of the Earth's shadow on the Moon during lunar eclipses
- The change in apparent latitude of key stars as one traveled south from Greece to Egypt

But to the average person the world remained flat.

The World becomes Round

In the 16th century as cross-Atlantic and around-the-world exploration became common, the reality of a round world sank in. Ever since, the spherical nature of the world has become ever more assertive as we have developed one new method of swift communication after another. When the first telegraph and telephone lines were laid across the bottom of the Atlantic connecting North America with Europe in 1866, the effect on public world consciousness was considerable.

Not quite a century later, Telstar 1, launched July 10, 1962, brought live television pictures originating in the US to France that same day. Ever since we have enjoyed live newscasts and sportcasts from around the world. We not only shared one round world, we were now actively interconnected over very short time intervals.

And now we have the World Wide Web, the Internet. The World has grown a brain of sorts. The "noosphere" predicted by French Jesuit philosopher Theilhard de Chardin (died 1955) has become reality.

From Africans to Terrestrials to Solarians

During the past century or more, we have equated "World" with "Earth" but that perception, that identification, as logical as it now seems, is going to change. Think of it. The "world" can also be described, without prejudice to the definition I offered above, as **"a continuum of horizons,**

- **from no point of which, the whole is visible,**
- **but between all points of which,**
- **travel and communication may become routine."**

Communications with the Moon involves a delay of under 3 seconds, between Earth-Moon and Mars, between 6 and 40 minutes. Compare that with the delay in communications in the 16th Century -- as much as months -- when everyone accepted that all parts of Earth made up one world.

That "World" defines a set of routinely inter-communicating living spaces, is more apt a definition than any other that restricts "World" to any one celestial body. Now I put "routinely" into the definition to exclude possible extra-solar civilizations many light years apart, where sporadic one-way communications taking generations is possible.

"Our" world will, in time, include settlements on the Moon, expeditions in transit within the solar system, and outposts on Mars, and even beyond. You can get an answer to a question sent to an outpost on Pluto within a day, a lot faster than Queen Isabella and King Ferdinand heard back from Columbus.

The world, to future generations, will not mean "Earth."

It will mean the inhabited part of the Solar System.

Get used to it!

From just one Earth continent, to all of planet Earth, to everything in Earth's orbit around the Sun, to everything reachable within Earth's Solar System, the Epic of Human Expansion continues, and is inevitable. If it were to stop because of deliberately cherished ignorance or through a failure of will, mankind will have betrayed its mission. "Go and expand into all the world." "All the world" is on the verge of becoming "all the Solar System."

"World" is as inclusive as technology allows

Our world to the extend that it means "everything within our reach" keeps expanding as our technology keeps expanding. Our Epic has involved one great leap after another. The time has come for the next. Not to take this leap means to turn our back on the potential within us. It means to say "No" to God or to whatever forces you prefer to believe have resulted in our existence.,

Copernicus opened up our eyes to a universe populated by other worlds, this time used in the sense of planets, or better, as bodies which could conceivably be or become theaters of human or intelligent activity. But it is only the age of the rocket which has allowed human travel to "continents" across the ocean of space, that has brought us to this point. Tomorrow, "world" in the sense of the evening news, will routinely include venues beyond the "original" seven continents. With modern communications it makes no difference if we are reporting human news stories from the Moon, from Antarctica, from any other terrestrial "Timbuktu" or from elsewhere in our own local community. The boundaries of **"the theater of human life" commonly called "the world"** are expanding outward.

In the era when humans lived only in Africa, the "world" included but one continent. Even as humans expanded through Eurasia, we were still confined to one big interconnected supercontinent. That the "world" would leap ocean barriers to the Americas, Australia, and the Pacific Islands was the first giant leap, the point at which we became truly intercontinental, perhaps as much as 40,000 years ago. The intervening seas did not matter because we could travel and communicate across them, at first with difficulty, but eventually, routinely.

In the age of aviation, it has become irrelevant if there is land or sea along our route. Can "short" stretches of Earth-hugging "space" be any different? The spacial "straight" separating Earth from Moon is no longer a barrier to either routine travel or routine communication. The Earth-Moon system will become one "World."

Both travel and communication will take longer to other points in the solar system, but are of little consequence in comparison to the difficulty of travel and communication in the post-Columbus, post-Magellan world. To continue to think of "world" as confined to Earth, is to think in tribal terms.

This Epic leap is not yet a solidified reality. It will become so as early science outposts on the Moon are followed by civilian industrial settlements engaged in making a living by selling goods and services of use to those remaining on Earth and/or in Earth orbit, endeavoring to manage their growing energy and environmental issues.

In a very real sense, the global decision to expand our present global economy to include the Moon will be the most critical test humanity has ever faced. If we pass this test, expansion will continue.

- At no time in the past have we faced such an opportunity and temptation to say, "No, enough already!"
- At no other time have we had the chance to betray our self and our "mission," the ultimate test of human free will, to become or not to become "Solarians." **<PK>**

Grytviken, South Georgia Island – Lessons for Moonbase Advocates

By Peter Kokh


Grytviken: abandoned whaling town on north coast of South Georgia Island

http://en.wikipedia.org/wiki/**Grytviken** – http://wikitravel.org/en/**Grytviken**
http://www.mclaren.gs/**grytviken.htm** – http://www.youtube.com/watch?v=NQqjNnFBszw
Do check out the links above before reading further!

Grytviken, South Georgia is on the itinerary of many "Antarctic Cruises" – grave of Earnest Shackleton

http://www.polar-reisen.ch/images/**southgeorgiaplan.jpg** <– this map shows the location of Grytviken in a protected inlet along the North coast of the island.

Given the huge cost multiplier in transportation costs, a "purely scientific" analog of McMurdo Sound on the Moon could not be built, and if it were, could not be long sustained. Only exports to Greater Earth (read: Earth Orbit destinations) could justify building and sustaining a permanent, growing base on the Moon. That means that while such a base may support further scientific exploration and research on the Moon, it must be economically viable.

Grytviken and other whaling stations were sustainable as long as the South Atlantic whaling industry continued to thrive. The lesson? Production of products for use in Earth Orbit at a transportation cost less than equivalent products made on Earth can be shipped to orbit, is the only possible indefinitely sustainable foundation for any proposed outpost and for further expansion of human lunar settlements.

Building outposts to support tourism will only work if travel costs are greatly reduced and as settlements themselves become a tour destination for their architecture, biospheres, and unique culture. In time we will see both.

Made on the Moon Products that should be competitive in lLEO & GEO

- **Building Products:** items made of glass & glass composites, cast basalt and basalt fiber products, various metal alloys, other ceramics, concrete
- **Outfitting Products**, furnishings – Orbiting Space Hotels could have a decided "Lunar Ambiance."
- **Food, even water** could more cheaply be produced on the Moon and shipped "down" the gravity well to LEO/GEO
- **It takes 1/23rd the fuel** to bring an equivalent item from the Moon "down the gravity well" to GEO than it does to blast a similar item "up the gravity well" from Earth's surface. The advantage in shipping to Low Earth Orbit. LEO, is less, but still substantial. ##

Additional Reading:

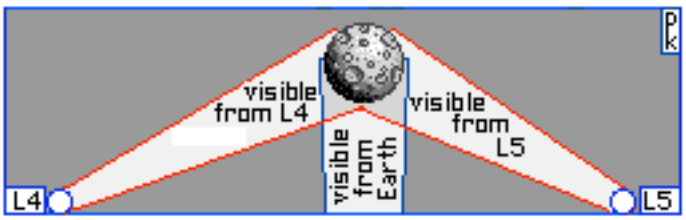
http://www.Moonsociety.org/publications/mmm_papers/muscle_paper.htm

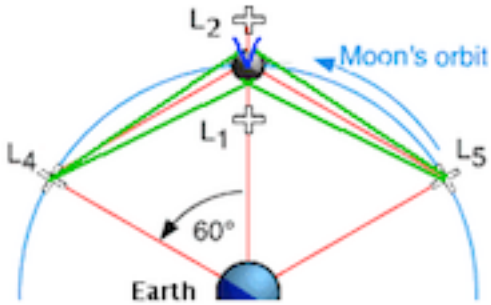
The "Flankscopes" Project: Seeing Around the Edges of the Moon

By Peter Kokh

It would be a very interesting project, and one bound to be endlessly productive, to send a pair of remotely operated space telescopes to the two gravitationally stable areas flanking the Moon in its orbit where Earth's and the Moon's gravities neutralize each other. In those two locations, known as L4 and L5 [see illustration below] these telescopes would keep their station without the need for fuel, for as long as they continued to function.

Built to be operated by amateurs and students, these telescopes would see 60° around the Farside of what appears to the Earthbound as the right and left edges, or limbs, of the Moon. This would give observers a chance to chart, explore, and familiarize themselves with about 67% of the back side of the Moon otherwise forever invisible from Earth.





The "full" Moon as seen from L4 - The "full" Moon as seen from Earth - The "full" Moon as seen from L5

From the L4 Flankscope, one could study Mare Orientalis, arguably the most fascinating multi-ring basin on the Moon; and many other interesting farside features. A bonus would be a much better look at nearside features near the limb, along the Western reaches of Mare Procellarum. From the L5 Flankscope, not only might we see the striking dark lava filled crater Tsiolkovsky and its bright central mountain, but we'd have better views of already familiar objects such as Mare Crisium, Mare Marginis, Mare Smythii, Mare Humboltianum, and Mare Australe.

These two new-New Full Moon portraits could become well-known among students, and among al fraction of the adult populations, worldwide. People would become conscious of the Moon as a whole globe for the first time. Only the 60 ° wide pie slice of center farside would remain out of view to people on Earth, and actually less than that due to libration effects whereby we can alternately see a few degrees further west towards center farside and then a few degrees further east towards center farside on a monthly rhythm.

So what's new about this?

Of course, we've all seen these areas from many angles including straight overhead thanks to lunar orbiters. But now these views will be real time, and especially, when observing features near the advancing or receding terminator, we'll get serial shots that could be turned into a video of sorts. Has anyone done this?

The two flankscopes could always be aimed at the center of the Moon's observable disk, 7°+/- 60°W and 7°+/- 60°E, producing a full view very high resolution real time image. An unlimited number of viewers on Earth could, via internet, live-search any part of that image that they wanted to study, and perhaps with better viewing than we have with our best amateur scopes from home - remember these

views are not through an unsteady atmosphere, but through vacuum. So even those who wanted to study the nearside, might prefer to tune in to one or both flankscopes.

It gets better: each flankscope platform could also have an a mate telescope turned back on Earth, so that two perspectives of Earth in high resolution were available at all times 24/365 and these two could be studied in detail zooming in on any part of the lie image. And that would raise the demand for yet another scope at L3, on the side of Earth opposite to the Moon, trained on just the Earth for triple double-overlaping coverage.

The money question: special views of Earth, day and night

Advertisers would pay for all these images to be available on a special channel, and people will pay for a device to "live search" any of these Moon or Earth images. Local TV stations could zoom in on live views of any part of Earth. Is it hoping two much that these two streams of revenue could finance the construction and deployment of both flankscopes? This is a far more ambitious project than that tried two decades ago by a team led by Rensselaer Polytechnic Institute in Troy, New York. It is this piggyback Earthscope feature that might just pay for the whole deal. The market, of course, is not only the media, but universities, airlines, etc. And you can imagine how many will enjoy the nighttime views with the city lights ablaze wherever it is cloudy. Again, zoomable.

So now those of us who would study the Moon through a telescope not only have something we would all die for, but a companion feature that will bring in enough advance money to pay for the project.

"As the Moon turns" (with respect to the Sun!) Of course, libration fudges that a bit, but the areas close to the limb are all but useless anyway, except for edge profile studies of altitudes.

Flankscopes always have perfect visibility (no weather.) When their field of view is "new" and a day before/after new, other observers could use them to study stars, asteroids, comets, and other planets

Should we dust off the **Ritchey-Chretien** Telescopes design involved in the previous effort? Or should we start fresh? We leave that to the telescope experts. There may well be new designs that could promise more and better features, designs that have evolved more recently. And our flankscopes would be fixed on target, with a searchable field of view, searchable by an unlimited number of users at any time.

If this idea is judged to have merit and survives peer review, many things need to be determined besides telescope design and operating equipment. There would have to be one or more "control centers." A university or consortium of universities would be involved.

Students at universities would get equal time with amateurs and vice versa. No problem! As we see it, there could be an unlimited number of users at any time as both flankscopes would be fixed on the center of the lunar field of view, producing a high resolution image of that face of the Moon, searchable by any number of users.

A Partial Precedent

The Rensselaer Polytechnic Amateur Space Telescope project of the late 1980s and early 1990s (?) aimed to put a telescope in orbit that could be used by students everywhere, not to study the Moon especially, but the stars. The project completed the telescope design but got no further.

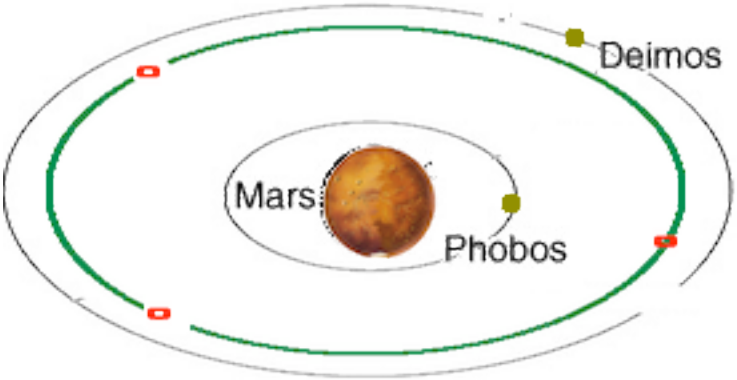
Here we do not propose to do the same thing at all. The flankscopes project would put up two identical telescopes, not necessarily similar in design to the Ritchey -Chretien telescopes planned for the Amateur Space Telescope, nor in low Earth orbit, nor to look as the stars. Instead the two telescopes would be placed one in the Earth Moon L4 position, the other in L5, at the same distance from the Moon as is Earth, but from different angles, seeing quite different overlapping views of the Moon.

I confess that I do not know enough about optics to venture a guess on how big such scopes would have to be to do the trick. Clearly our telescopes would be much more powerful, able to produce a high resolution of the entire scope-facing hemisphere of the Moon, differently searchable by each of an unlimited number of users via the internet. It is a more ambitious project with higher expectations and goals.

For all this it will require more money. It is for that purpose that we suggest the potential commercial uses of mated-Earth facing telescopes on each platform, at L4 and L5. The writer is not known for his financial insights and expectations. The suggested financing may be quite unrealistic. But making errors has value if it bothers someone else to the point that he/she comes up with a better way. So we put this proposal before our readers in **MMM**, in the **MMM India Quarterly #19**, and in the **To The Stars International Quarterly #5**, PK

POSTSCRIPT sent to Mars: If this idea survives review and attracts financing, why not follow up with something similar at Mars. Here we would put **3** telescopes in **Mars Synchronous Orbit**, a bit inwards of Deimos orbit.

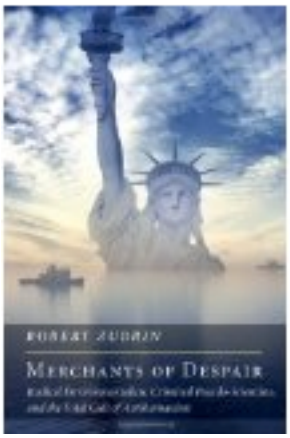
We might want communications satellites at those locations as well. Three "hemispheres" overlapping 60° on each side constantly in view via internet to observers on Earth might lead to a more thorough study of Mars' surface, and a better appreciation of its global assets, as well as more support for human exploration of the Red Planet.



Teleoperated from Earth with clumsy time delays, the effect would be to greatly spread knowledge of Mars among the public. That could lead to more ambitious plans to explore and even someday populate the red planet. PK

BOOK REVIEW: **Merchants of Despair: Radical Environmentalists, Criminal Pseudo-Scientists and the Fatal Cult of Antihumanism**

BOOK REVIEW By David Dunlop



Robert Zubrin, copyright 2012
ISBN 978-1-59403-476-3
Encounter Books, an activity of
Encounter for Culture and Education

Merchants of Despair: Radical Environmentalists, Criminal Pseudo Scientists, and the Fatal Cult of Antihumanism by Dr. Robert Zubrin might be surprising to find in a publication devoted to space such as To The Stars International Quarterly. It's author, Bob Zubrin, is famous for his book **Mars Direct**, as the **founder of the Mars Society**, and as an informative and engaging speaker. Zubrin is "no shrinking violet" and plunges into the fray in talking about issues pertaining to human rights, environmentalism, political movements and the scientific "spin" placed on public policies.

I highly recommend this book. In this book Zubrin might be described as a master curmudgeon, taking on policies and practices that are often considered mainstream. He skillfully demonstrates both why and how scientific skepticism is practiced. I will not so much discuss or summarize his arguments or review his topics as I encourage people to read for themselves. His challenges those who embrace the pessimism of Malthusian economic ideology, projections of over population and scarcity, and global calamity as a logical an inevitable consequence of too much humanity.

I think those who purchase this book will be richly rewarded by Zubrin's grasp of both the facts and the issues, his command of history, and his clear voice as both a scientific and political skeptic of what is uncritically accepted as "conventional wisdom" in public policies on population control, energy policy, and environmental "reform". For someone who is so identified and prolific in his vision for the expansion of humanity to Mars and other destinations beyond the Earth there is scarcely a word about that planet. DD

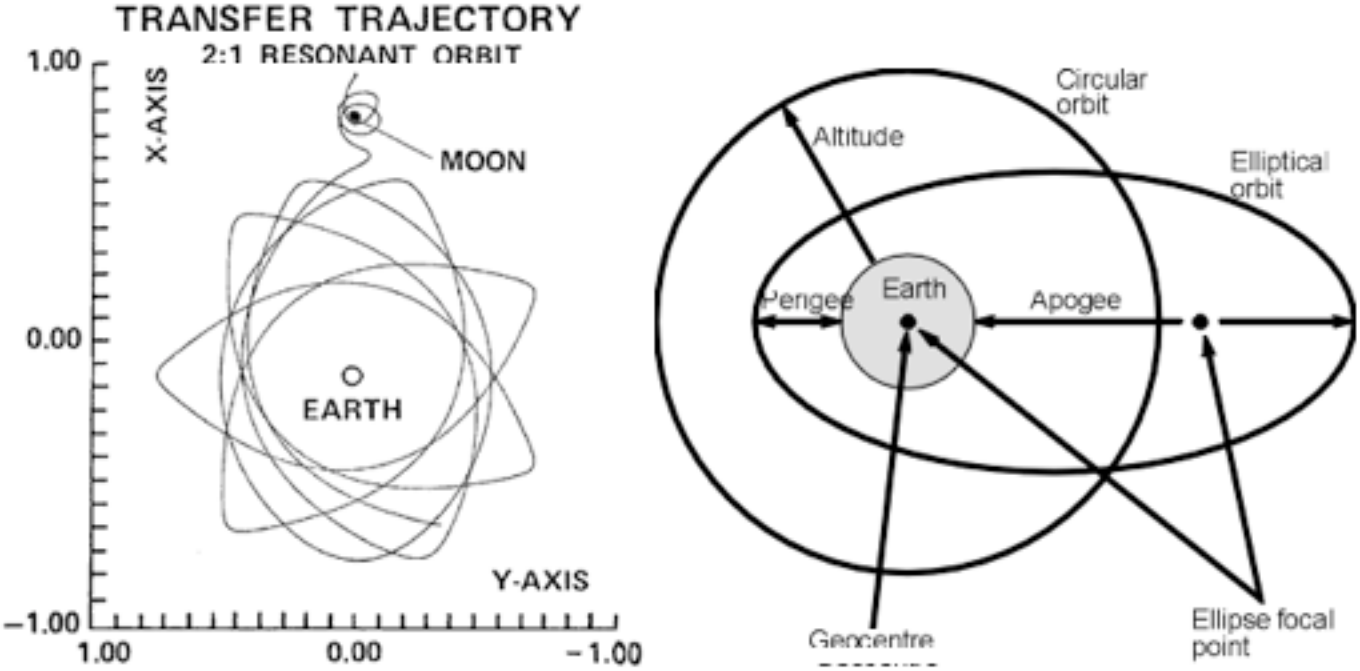
Integrating Cycling Orbits to Enhance Cislunar Infrastructure

By Al Anzaldua*

Much has been said about NASA's recent proposal to put a human-tended waypoint, i.e. a crewed station and staging area, at Earth-Moon L2 (EML2)[1] as a starting point for further expansion into the solar system, and in particular, as a waypoint to Mars. Also stirring comment is NASA's proposal to "lasso" a small near-Earth asteroid (NEA), or take a chunk out of a larger NEA, and bring it into orbit within the Earth-Moon system so that astronauts can visit it to take samples. Parties interested in these proposals in and out of NASA also see the potential of EML2 as a multifaceted infrastrcture hub.

What could such a hub consist of? To begin with, structures in halo orbits around EML2 would only need propellant for station-keeping and could form the nexus of an integrated transportation system, equipped with docking and fueling stations and connected to reusable in-space tugs, tankers, ferries. Beside transportation capacity, other EML2-based infrastructure could include or be connected to: 1) lunar materials processing and shipping sites, 2) near-Earth asteroid (NEA) resource processing areas, 3) lunar farside telerobotic science platforms, 4) assembly and staging sites for solar power satellites (SPS) and spacecraft, 5) communications platforms to facilitate lunar farside radio astronomy, 6) radiation-shielding test sites, 7) variable-gravity centrifuge test sites, 8) test beds for controlled or closed ecological life support systems, and 9) tourism facilities.

The potential for EML2-connected infrastructure is indeed staggering, and the same could be said of EML1, although in the latter case, lunar farside telerobotics or telescopes would not be feasible. One thing that is rarely mentioned about EML2 infrastructure, however, is that EML2 is a also perfect jumping off site to a perpetually cycling Earth-Moon 2:1 Resonant Orbit (cycling EMRO) and other cycling Highly Elliptical Orbits (HEOs), which would enhance any infrastructure architecture connected to it.



T. A. Heppenheimer in his landmark book, Colonies in Space,[2] described the advantages of putting a space habitat in a cycling 2:1 EMRO. According to Heppenheimer, a spacecraft could reach such an orbit from EML2 with a delta V (i.e. change in velocity) as low as 9.1 meters/sec (30 feet/sec or 20.5 mph). And once a vehicle, station, or habitat is built or emplaced in such an orbit, it will cycle indefinitely in slightly less than every two weeks, with each revolution passing around the Earth as close as 160,000 km, and then cycling very close to the Moon and back.

A structure built or emplaced in Heppenheimer's cycling EMRO would conceivably need no propellant, except possibly for attitude control or docking maneuvers. As a supplement to reaction wheels, light propulsion could be supplied by Solar Electric Propulsion (SEP) engines. While a structure in a bean-shaped orbit around EML4 or EML5 would be in the same happy situation, it would take much more propellant to get from EML2 to either of these latter sites, than to reach EMRO or other HEOs. (Delta v from EML2 to EML5/L4 = 427 meters/sec or 1400 ft/sec versus 9.1 meters/sec or 30 ft/sec to get to EMRO.) Moreover, according to John S. Lewis in his 1996 book, Mining the Sky, the propellant cost to reach HEOs[3] from Low Earth Orbit (LEO) is less than to get to geostationary orbit (delta v of 3 km/sec [1.86 mi/sec] versus 4 km/sec [2.48 mi/sec]) because in the former case there is no need for an orbit-

circularization engine burn. It is also much easier to get back to LEO from HEO to Low Earth Orbit (LEO) than from geosynchronous (GSO) or geostationary orbit (GEO).

The point here is that spacecraft, crewed stations, and habitats in EMRO and other perpetually cycling orbits could synergistically enhance and expand a cislunar transportation system and economy. Habitats, whether hotels or worker camps, could be spacious, rotated for artificial gravity, and built up incrementally to withstand galactic and solar radiation. For vehicles, the disadvantage of Earth-Moon HEOs is that they generally offer a slower route to cislunar destinations than other trajectories. Earth-Mars Cyclers, however, have a different problem in that small high velocity "taxis" and freighters would be needed to reach such cycling structures. In either cycling system, the main benefit is that reusable spacecraft carrying cargo or well protected passengers would be able to save many tons of propellant by connecting to cycling orbits to reach various solar system destinations.

Enhancing the EML2 Integrated Transportation System with Cyclers

An Integrated Cislunar Space Transportation System is "Milestone 3" of the recently published, National Space Society Milestones to Space Settlement, also known as the "NSS Roadmap." Furthermore, National Space Society (NSS) member John Strickland has in recent papers and lectures[4] elaborated the essential elements of such a system. From all these sources it is clear that structures in halo orbit at EML2 or EML1 are central to any effective cislunar transportation system, and facilities connected to these sites are critical to maintaining cislunar infrastructure.

For example, lunar ice and other volatiles from perpetually dark south pole craters could be transported first to a EML2 site in halo orbit for processing into fuel, drinking water, and oxygen to breath -- and then to EMRO facilities for delivery to refueling and life-support stations in Earth orbit. The same procedure could be used to deliver lunar metals to make solar power satellites (SPS) or comsats, which then can be moved to geosynchronous or other Earth orbits. The top of Malapert Mountain, near the Moon's South Pole, because of its continuous illumination and line-of-sight to Earth, could be an initial lunar base to exploit lunar resources and coordinate these deliveries.

Other Earth-Moon cycling orbits exist, which require little propellant to perpetuate, and might be even more advantageous for certain applications than Heppenheimer's EMRO. For example, John S. Lewis in Mining[5] speaks of HEOs, which could reach in as close as 1000 to 2000 kilometers at perigee and as far as 100,000 to 400,000 kilometers at apogee. According to Lewis, the beauty of these orbits is that HEO is not only easier to reach from EML2/L1 than GEO (see above), but is also much easier than GEO to get back to Low Earth Orbit (LEO) or cislunar orbits. For this reason, a HEO base would make an attractive staging and processing site for the retrieval of asteroidal metals and propellants, the fueling and launching of planetary exploration missions, and the construction of large permanent space structures. Using a factory in HEO to carry out the construction of solar power satellites (SPS) mostly from lunar and asteroidal resources also makes tremendous sense. And since HEOs can reach almost to the Moon, moving lunar materials from HEO to EML2 or L1 would require very little propellant.

Cislunar Cycling for Tourism

The tourism potential for cislunar cyclers deserves special mention. We have already seen that some people are willing to pay handsomely for a trip to the International Space Station or even for a suborbital trip. One can only imagine the people that would line up for the awesome views a cycling trip to the Moon and back would provide. Buzz Aldrin in his recent book, Mission to Mars,[6] says of cycling lunar tourism destinations:

"I foresee an**X** interplanetary cruise ship, a lunar cycler. Assembled in Earth orbit, this liner is given a powerful push – sending it on its way to the Moon. The lunar cycler will…loop around the Moon, return to Earth, slingshot around the Earth, and return to the Moon again [in] just over a week. And every time the lunar cycler swings by Earth, it'll be met by a supply ferry…restocked…and boarded by a fresh group of travelers."

Clearly Dr. Aldrin's proposed Earth-Moon cycler is not the same as Heppenheimer's two-week EMRO or Lewis's HEO, but the idea is the same. The beauty of the cycling concept is that many such orbits are possible within our solar system, each bringing its own special enhancement to living and working in space. Some of these orbits would need propellant to maintain, but the payoff might be worth it.

Connecting to Mars Cyclers

Heppenheimer's EMRO and other Earth-Moon cycling orbits could conceivably be integrated into other cycling orbits to bring solar system infrastructure to Mars and beyond. The cycling orbits proposed by Dr. Buzz Aldrin in Mission[7] make a rational case for establishing the equivalent of a "transcontinental railroad system" in space by making use of perpetual cycling orbits to Mars and back. Dr. Aldrin proposes constructing a pair of "Purdue/Aldrin" cyclers with trajectories that would make close flybys of Earth and Mars every 2 1/7 years and needing only small amounts of propellant to give well-timed "nudges."

Because each cycling vehicle as a leg to get to either Mars or Earth in less than six months, however, travelers can avoid the 20 month leg by hopping off one cycler near Mars and then waiting for the other vehicle to take for a six month trip back to Earth. Dr. Aldrin also notes in Mission that at least four other Earth-Mars cycling trajectories have been inspired by the Purdue/Aldrin Cycler concept idea.

According to Alan Bellows,[8] NASA in 1999 estimated that a rocket-powered manned mission to Mars would require 437 metric tons of mass to be lifted into space. This translates into $8.74 billion to orbit the materials for one round trip to Mars. Over half of that weight-- 250 tons—would be propellant. As Bellows notes, a cycling spacecraft approach would represent rational re-use, rather than a system that litters space with discarded multi-billion-dollar vehicles and other structures. Of course, a vehicle would need an initial thrust to insert it into the cycler "sweet spot".**X** After that, however, only minimal propellant would be necessary to maintain the rhythmic encounters or to move to another orbit.

Going Beyond Moon and Mars

Finally there is the "Interplanetary Superhighway," proposed by Martin Lo and Shane Ross,[9] a gravitationally determined set of pathways between solar system Lagrange (L) points within which a spacecraft can traverse. Also known as the "Interplanetary Transport Network," a vehicle traveling through this system could make use of cislunar and other L points to change trajectory and move on with very little fuel cost. Such a spacecraft would move slowly, however. Yet it could be well worth exploring whether automated tankers and freighters from cislunar points and cycling orbits could connect to this system to make deliveries that are not time sensitive.

X This article serves the purpose of expanding the concept of cislunar infrastructure by introducing the possibility that it can be enhanced by use of various solar system cycling orbits. I also hope that others will develop more comprehensive and detailed descriptions of such expanded transportation networks. The overall goal should be to facilitate people living and working in space so that we humans can eventually become a multi-world species, and thereby ensure our long-term survival.

Notes

1. Technically, EML2 is in the "trans" position vis-à-vis the Earth-Moon system. But I bow to common usage and will treat EML2 as part of cislunar infrastructure.
2. T. A. Heppenheimer, Colonies in Space, 1977, pp.110 - 112.
3. J. S. Lewis, Mining the Sky, 1996, p.134. Lewis calls HEOs Highly Eccentric Earth Orbits.
4. J. Strickland, "Cis-lunar Transportation – The Space Trucking System," The Space Review, Jan. 21, 2013 and "The Cis-lunar Gateway with No Gate," The Space Review, Oct. 1, 2012 and "Orbital Propellant Depots: Building the Interplanetary Highway," NSS Website, Aug. 15, 2011.
5. J. S. Lewis, Mining the Sky, 1996, p.132.
6. B. Aldrin, Mission to Mars, 2013, p.52.
7. B. Aldrin, Mission to Mars, 2013, pp. 195 – 199.
8. A. Bellows, Blog: Damn Interesting:The Martian Express, 2008, Article #319.
9. M. W. Lo and Ross, Shane D,. 2001, The Lunar L1 Gateway: Portal to the Stars and Beyond, AIAA Space 2001 Conference, Albuquerque, New Mexico.

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The Responsibilities of Dual Citizenship for Our Economy, Our planet, and the Evolution of a Space Faring Civilization

By David Dunlop, August 2, 2013

Everyone on this planet lives in the context of the nation-state. Although systems of government vary, and the range of freedoms and opportunities vary from political system to political system everyone can be said to have citizenship status. Everyone is a members of a national group and have certain obligations and responsibilities. Now some live in remote areas very difficult to access are remote and are perhaps even unaware of their membership in a nation state. Others, may not wish to be members of a nation state of which they are an unwilling part.

They may aspire to have their own sovereign territory independent of the larger nation. History is full of such examples. My point is that the status of everyone as a member of a nation state involves

certain awareness and responsibilities to one's national group and its associated territory. National Political systems also vary in the demands they make on their citizens. It is common for nation states to demand various kinds of services from their citizens. To defend the territory of the nation. To pay taxes to support needed services. To observe certain historical, religious, practices common to the nation. To be self-sufficient and contribute to the economic welfare of the nation. To acquire and practice expertise which is needed in the areas of commerce, science, medicine, law, education, agriculture, etc.

Everyone on this planet lives in the context of being also a global citizen whose existence on this planet is shared with many other human beings not included in his nation state and importantly other forms of life, planets and animals.

This larger context is one where our understanding of our shared planetary sphere is growing ever greater. Who can deny that all humans share an existence on this planet. Who can deny that our planet is small in relation to many other planets in our solar system and unique in supporting the diversity of life we observe all around us on this planet? Who can deny that the pressing needs of a global population increasingly strain the ecosystems of this small planet. Who can deny that the resources needed in energy and minerals, and fresh water are insufficient for the ambitions of all the citizens of our small planet?

On this small planet we find great difference in the local resources available to the nation states. Some have an abundance of resources such as fertile agricultural land, fresh water, forests, mineral resources, and access to the world ocean. Other have mostly desert land, little fresh water, few fertile agricultural lands or forests, and no access to the world ocean. In a world tied together by cheap global communications these differences produce dissatisfaction with the consequences and economic circumstances that produce great wealth and abundance on the one hand and that limit wealth and make needed resources scarce on the other.

So each individual is both a national citizen, a world citizen, with few unaware of global problems and opportunities, wealth and poverty, and with obligations to participate. In the real world it seems clear that the limits of the Earth have and will create clashes in the ambition of both individuals and nations states to secure necessary resources. This is the pattern of human history, a history also of war, destruction, mutual inhumanity, and glorification of a winner take all competition that some tend also to see as “evolutionary competition.” There is a self-deluding tendency to believe that “we” will be on the winning side of this evolutionary competition and that extinction will not be our reward.

The development and use of nuclear weapons in WWII and afterwards however brought such national competitions to the point where **Mutual Assured Destruction** was a clear consequence to the use of such weapons. This understanding on the part of those nations possessing has made them embrace arm limitations agreements as a way of reducing the risk of nuclear calamity and perhaps a self induced extinction event for our species. It has also encouraged those powers that have developed such nuclear weapons to live together in some sort of stable accommodations and to also favor the limitation of the further spread of those weapons. For the peacemakers the understanding of **Mutual Assured Destruction** as a strategic concept has been a positive result, and the avoidance of nuclear war is something the “great nuclear powers” have come to understand only too well in their own self interest.

So having faced **Mutual Assured Destruction** of the nuclear kind we are now also aware that this concept can manifest itself in other ways. The space age has brought global awareness to those countries with space-based capabilities. They have the capacity to build and launch rockets and satellites which can observe the Earth and even travel to the other planets in the solar system. From this ability over the last 55 years our understanding of our own planet and our own impact on our planet has been transformed. Those space powers also have vastly improved understanding of their own national resources and their limitations as well as an understanding everyone's resources and a picture of the planet as a whole.

The increased awareness also raises again the specter of **Mutual Assured Destruction**, not only from competitive national aspirations and ambitions of one nation struggling with others for access to needed resources (from around the world as well as within its own borders) but from an unexpected direction. The material success of scientific advances, and industrial activities have raised the living standards of billions of people to levels undreamed of just a century ago. The use of energy resources on a global scale has increased and both communications, transportation, agriculture, systems have created standards of living that previously only a tiny elite could experience.

We see the revived specter of Mutual Assured Destruction in several dimensions.

- First our industrial scale pattern of consumption of the Earths resources is unsustainable.
- Second, our pattern of consumption is destroying many of the Earth's ecosystem and we are creating a great extinction event for many of the other species on this planet through the destruction of their natural habitats.

- Third our pattern of consumption and production is creating further geopolitical instability between the haves and have nots both within and among nation states. While the rise of living standards has benefited billions many are left out of these gains, both within the nation states and elsewhere around the globe. With both global and national communications creating global awareness those without a share of this wealth aspire to have the same opportunities and lifestyles as those that do have the wealth.

If these aspirations are not satisfied the predictable result is both internal and external social and political conflict. Fortunately, continuing advances in science and technology make us of aware of not only these problems but of potential solutions and the necessity of their adoption.

The World Watch Institute in Washington D.C. Has indicated that based on the levels of production and consumption at present "we" the world would need two to three Earths to sustain the current level of economic activities. Yet if all of the world's seven billion people where to consume the levels of energy and resources of the the "first billion" of the economically advantaged, "we" the world population would need 8 to 10 Earth's. Our success in raising living standards, in developing a global system of commerce, trade, production, in building large urbanized environments spreading relentlessly over the landscape, and in consuming ever increasing amounts of fossil fuel energy and materials are creating another scenario of **Mutual Assured Destruction** in terms of resources exhaustion and potentially irreversible climate change.

As global citizens we face a stark choice between over consumption, environmental destruction and resources wars or alternatively obtaining space based energy and resources and doing so within a cooperative and collaborative framework that sustains and repairs the Earth.

Against this mixed picture of human success and potential self-destruction is the possibility of securing the resources of the inner solar system to alleviate the shortages of the Earth's ecosystems and mineral resources. We might call this scenario **Mutual Assured Production**. If we can learn to live and work and secure the resources of the solar system then we can find it possible survive sustainably on Earth with social and economic equity.

If we can learn to live and work and secure the resources of the solar system we can expand the reach of humanity to other potentially favorable destinations in the inner solar system such as the Moon, Mars, the largest asteroid Ceres and others. We have at great cost learned to peek above our planet's atmosphere with advanced ground based as well as space telescopes and see what else is out there. There is an abundance of asteroidal materials in the warm center of our solar system where the energy of our Sun can be harvested, both from Near Earth Objects but further out in the main belt.

Destinations

The closest resource is that of our Moon. Its surface area is equal to the combination of Africa and Australia, and some have called it our "Eighth continent." It also is bathed in the sun's radiation so solar energy is a powerful potential resource on the lunar surface. While it is largely deficient in water we have recently learned that it has more than previously understood. It is undoubtedly enough to permit some sustaining human and industrial presence if this scarce resources is carefully managed.

The Moon and near Earth asteroids also offer the potential of construction materials for large solar power satellites that could provide a clean sustainable source of energy to the entire world population of 7 billion going on to perhaps 10 billion people by the end of this century. A global system of such satellites is now technically foreseeable. A global effort to realize this potential would be the first major objective of a global program of **Mutual Assured Production.** Dr. Abdul Kalam, former President of India has called for **Space-Based Solar Power for a Livable Earth** in a joint initiative with the National Space Society.

This first objective could produce a system that would permit everyone on Earth in both cities as well as in remote areas to have access to abundant electrical energy supplies. Early prototypes satellites might be used to supply electrical power to areas that have suffered from natural disasters where electrical grids and power plants have been destroyed or disrupted or where power might be beamed to remote areas where refugees are beyond any power grid. This humanitarian demonstration would be an appropriate first demonstration of the flexibility and practical utility of this technology. Its international usefulness as a political demonstration of goodwill and sustainable economic development in practice could also apply to the fact providing emergency power is also some of the most expensive power provided. Therefore the initial high cost satellite power can be morally as well as economically justified in early demonstrations that are likely to be welcomed under emergency circumstances.

The second objective of this satellite system would be its expansion to permit desalinization of sea water and its movement to where ever it is needed. This de facto creation of an "artificial rivers" system bringing vast quantities of clean water to areas of scarcity uphill from the ocean is an additional goal addressing problems of agricultural production, and scarce water supplies for growing cities.

A Third objective of this system would be the expansion of power and water supplies to permit environmental restoration of damaged lands, and widespread reforestation of the planet to produce not only forest products but the reconstruction of habitats to sustain the ecological diversity of the Earth. **Mutual Assured Production** must be used to stop the mass extinction of other species that has resulted from the over reach of civilizations' draw of the Earth's limited resources and space.

A fourth consequence of Mutual Assured Production is the **construction and reconstruction of urban environments that provide a high standard of living for humanity but with a much more limited environmental footprint.**

Closed environmental agricultural systems in urban environments can provide an abundance and diversity of food to the human population without requiring the habitats of other species to be eliminated. The challenge of creating sustainable environments in space can also be engineering models for urban environments on Earth where these design constraints can actually help us raise the living standards of terrestrial civilization while vastly reducing the environmental footprints. Moving to space will therefore gives up the experience teach us the self discipline to live on our natural planet to best effect.

Space Environment Construction

The vision of the expansion of humanity to the other destinations mentioned the Moon, Mars Ceres, and the asteroids also includes the construction of cities in space. Such constructions must be engineered to vastly improve the recycling and reuse of resources as a basic matter of survival in the space environment. So the fifth consequence of **Mutual Assured Production** is the spread of human environments. Often neglected in this discussion of the future construction by its founding proponents such as Buckminster Fuller, Gerhard O'Neil, and Paolo Soleri is the issue of the creation of habitats which permit not only homo-sapiens to survive but also all the co-dependent species on which human survival is predicated, the web of life. The Biosphere II was an early attempt to address this prospect following the philosophy of James Lovelock, Lynne Margulis, and Merle Jenson among others. Its work demonstrated how far from a genuine understanding we have of this challenge to create a sustainable extension of terrestrial life to these other destinations.

So this Grand Prospect of **Mutual Assured Production** is a global challenge that must embrace the aspirations of global citizens regardless of their dual citizenships as citizens of nation states. It is the privilege of the richer and more technologically advanced countries to begin this global initiative and to bear the economic burdens to ensure that this project is started. Unfortunately much of humanity and the nation states in which they reside do not have the financial or technological capabilities to begin. They struggle for basic sustenance and many are close to being failed states. But these initiatives are important for they give hope to all from the richest to the poorest of a better and sustainable future. These initiatives also promise unimaginable additional wealth as a consequence. Those who make these investments will realize a great return on this investment and those who are unable to make this investment will see their access to essential resources and associated opportunities vastly increase. They will therefore also have an opportunity to obtain a great deal of additional wealth not possible under their current circumstances and limitations. Mutual Assured Production is a global win-win.

Our dual citizenship is based on global awareness on Earth and of the opportunities and challenges in space first around our Earth Moon System. This also includes the utilization of Near Earth Objects as material resources and the development and utilization of cislunar space. Mars beckons us as our potential “second planet” with a surface area equal to the dry land on Earth. It is distant but accessible if we make a concerted effort to develop the needed infrastructures. If we succeed in cislunar space and extend out to Mars we have won in essence a planetary Trifecta, saving the Earth, gaining the Moon, and winning an entire second planet Mars. The further prize of Ceres and other large asteroids as places of human settlement and construction of human settlements for a sustained existence is a further diaspora in the warm heart of our solar system.

As citizens of nation states we have a simple choice between **Mutual Assured Destruction** as a social policy of competition for scarce and diminishing resources and environmental self destruction or as global dual citizens choosing the other option of **Mutual Assured Production** using the vast energy resources of our sun and the material resources of the inner solar system. Our dual citizenship does not diminish our identities as citizen of proud nation states but enhances them as societies that can survive and thrive into the future on a beautiful and unique planet as well as extend to other destinations. As we move forward into the 21 century the starkness of these two choices becomes increasing clear. As dual citizens we must expand our awareness of the opportunities to support a program of Mutual Assured Production and encourage our governments to enlists in this grand enterprise.

A small beginning step is as citizens of our nation states to encourage our national participation in the Kalam NSS Initiative for Space Solar Power as an International undertaking to build a Global Knowledge

platform and Virtual Research and Development Institute of Space Solar Power and and to encourage national cooperation and collaboration in research and development initiatives. This might be done in conjunction with the United Nations University by forming a specialized Institute inviting the collaboration of many research institutions and universities and financial support through the G-20 countries that have both financial resources and the technological system and space agencies to participate.

Common Goals

The nation states have in a Program of Mutual Assured Production common interests and goals.These include:

1. Lowering the cost of access to space,
2. Assuring the peaceful access and use of space fulfilling the International Space Treaty
3. Dealing effectively with the problems of man made and natural space "debris" including planetary protection measures to detect well in advance and defend against large impactors.
4. Creating infrastructures that can create the space solar power satellites in cislunar space.
5. We should also encourage ongoing efforts to develop commercial fusion technology which could be an alternative clean energy supply system for humanity. Break throughs in commercial nuclear fusion might obviate the need for solar power satellites but such systems could be powered from fuel obtainable on the Moon and elsewhere in the solar system. Fusion plants would be essential to creating and sustaining human cities in space far from the Sun and in supplying for transportation, warmth, and materials processing in the cryosphere (extreme cold zone) that comprises most of the mass and volume of our solar system.
6. We should also fulfill the spirit of the International Space Treaty that the resources of space are the common heritage of humanity. It will take the investment of considerable resources of the rich technologically advanced nations to do the work needed to develop the resources of space but which must create a common marketplace where all of humanity can reach out and participate in to this abundance, regardless of some nation state's financial limitations at the beginning. This must be organized so that prospects for expanded participation are provided as the Mutual Assured Production program for space based resources develops. We must create a cislunar econosphere that transforms our global economic and environmental system and opens the door to lunar, Martian, and asteroid resource utilization and human settlement as well as human prosperity, justice and equity.
7. Encouraging education and contributing to the fund of open and common scientific knowledge so that people all over the globe can realize their potential and contribute to the vast enterprises that are part of a global program Mutual Assured Production of space based resources.

Summary and Conclusion

The responsibilities of citizenship are both national and global. They require participation within one's own national system but also an awareness and responsibility to the problems faced by the global environmental system and the vast social problems resulting from the collision of growth on the one hand and scarcity of terrestrial resources on the other. The the world's geopolitical system can head toward lose-lose outcomes from Mutual Assured Destruction of many kinds or win-win outcomes from Mutual Assured Production and access to space based resources. As we become more aware of our planetary problems and the hope of planetary opportunities we have a dual citizenship responsibility to advocate and work for the later. The Kalam-NSS initiative for Space Solar Power and a Livable Earth is an early first step for a hopeful future. DD

Dueling Space Roadmaps

By Dave Dunlop - August 6, 2013

Background:

I have seen the Space Frontier Foundation video There Is Another Way" which has much merit. It is a largely US centric proposal but I would encourage our readers to take a look: http://spacefrontier.org/thereisanotherway/

largely agree with this strategy but have added some variations and additional elements that provide in my opinion a more realistic view of how this scenario can be accomplished. My primary criticisms are that this is a very simplified scenario and the numbers provided seem optimistic.

They do positively contrast the current NASA monopoly way of doing business. That would be much more expensive and take much longer rather than with a model which uses "New Space" to do things more cheaply and more quickly. Naively however, national politics are ignored.

National funds at present of course are the major economic determinant of what is financially feasible. My own view is that this should also be a vision that brings the world along beginning with our ISS partner nations. The redundancy of an international supply chain was proven to be critical for the ISS and should be no less now for an Earth Moon gateway or Lunar and Mars surface programs. The international tax payers are still paying for these scenarios so while they use commercial contractors **they largely do not have mass commercial customers outside this context**, at least until ISRU resources start to come into play. International Treaty commitments are also more likely to be honored as opposed to just domestic proposals by the US Congress.

I have my own views of the way forward and have expressed them below. The Space Frontier Foundation plan is mostly US centric but I try to reflect a broader point of view. I am also limited by what is most familiar to me and accessible in terms of NASA's space program, and other players in the US space industry and the US political system. I do however want to indicate that while the program I describe is done so in US terms it is really better undertaken with international partners and investors. It should be the Next Big Thing in relation to the ISS and those international partners and with more added.

We have built and should continue to operate the ISS until 2028 at the least. We must push our international manned and commercial space capabilities beyond LEO. We must continue and strengthen our international partnerships from the ISS and expand them but we must also include the commercial sectors and international investors as having seats at the table from the beginning in this next step. We must also open the door for greater commercialization and investment as we go along. So with those apologies and qualifications let me begin.

Given the current US political climate the Earth-Moon L-2 Gateway (E-M L2) proposal I think has a chance of getting Congressional support from both sides of the isle. The SLS (Space Launch System, NASA's next big launcher intended to replace the Shuttle): and Orion (7-person manned capsule) supporters (Republicans) see it as a justification for the big launchers (ULA) and the use of Orion for long duration missions and jobs at the Marshall, Kennedy, and JSC centers and their contractors. L2 is my choice because it permits lunar farside utilization and is otherwise largely equivalent to the L1 choice of the SFF.

Boeing could see its fuel depot proposal become part of this program at both LEO and E-M L2. And indeed a number of companies have ambitions in this area. This means more launcher business as well. The reusable Falcon 9 "Grasshopper" vehicle could really make the space depots a game changer in bringing up the fuel at a much lower cost and therefore making in space refueling an affordable reality. It would also support "in space only" reusable vehicles that would be more cost effective than throw away expendables. Such vehicles would include cyclers between LEO and L2 as well as reusable and refuelable lunar ferries.

The ISS Gang

The other international ISS partners could still use their existing launchers as well if they can be modified to accept fuel transfers in orbit. So Ariane V, and the Japanese H-IIB get an additional lease on life for for deep space missions from their own space agencies as well as lunar supply missions. The Russians could do that as well for their new Angara rockets. This could apply also to India with its PSLV with its Lox-Hydrogen second stage and the proposed manned capsule.This extends the life and the utility of the space infrastructures of those ISS partner countries and others that have launchers that might want to become partners.Cost effective reusable rockets however will quickly make these heritage launch infrastructures obsolete. With more flight opportunities there is the potential for these operations to also become more cost efficient. Space X's grasshopper Falcon 9 will quickly precipitate a international reusable launchers competition and evolution.

New Space Growing Up

The New Space providers can see a potential for commercialization and the potential for Space-X to get there with a Dragon modifications and similarly so for the Boeing CST-100. The Falcon 9 Heavy could also be a big part of heavy lift as well so they could see a market for the Falcon 9 Heavy. Bigelow could provide inflatable modules. We could see increased of the Taurus II and Cygnus from Orbital Sciences in the supply chain. StratoLaunch could also come into the supply chain. The Commercial contract providers Space-X with Dragon, Boeing CST-100, and Sierra Nevada Dream Chaser should provide redundant supply chains for US manned access to LEO. This will make the staging of E-M L2 more reliable in the face of potential failures and also provide for an increase flight tempo needed to both maintain the ISS and develop the E-M L2 destination.

Whetting Lunar Surface Ambitions

E-M L2 also sets the stage of further lunar commercialization efforts. Moon-X and Astrobotics can

fulfill their ambitions to both be lunar transportation companies. Moon-X also has ambitions to be a lunar resource development company. Golden Spike can also play a role of transporting people to the lunar surface. The E-M L2 station is a back-up and rescue system waiting to provide risk reduction for Golden Spike. Shackleton energy is also a company that wishes to develop lunar surface capabilities in a number of directions. E-M L2 is also in line with prior work on the alignment of national architectures for lunar exploration. The European Lunar lander project is an example of this blended scenario. The international robotic village concepts that have been explored by Russia, Japan, and the Europeans fit well into this follow-on scenario. It would also encourage India to continue its Chandrayaan mission series.

E-M L2 also sets up an important communication link for lunar farside operations and as a point for lunar surface positioning. A cislunar communications and positioning system is not mentioned by SFF but is an essential piece of infrastructure for going beyond LEO. This is another potential commercial opportunity, perhaps the first of an international "space utility" delivering services to both national space agencies as customers as well as new commercial customers operating in cislunar space. United Societies in Space has chartered an International Space Development Authority Corporation as a legal structure to develop such space development services and infrastructures.

The Lunar Science Community can see an E-M station as a place where lunar telepresence missions can support additional affordable robotic lunar surface exploration and construction. As the E-M L2 station evolves it can also support Lunar surface human mission sorties especially when a reusable lander is developed that can be refueled at the E-M L2. This system can emplace radio astronomy facilities on the far side. It can widely expand the geophysical network needed to further the understanding of the geophysics of the Moon and to at last provide a more representative sample of the Moon surface than the Apollo samples. It can also enable lunar commercial operations. The NASA Lunar Science Institute has a network of international partners so a wider lunar science community that can utilize these capabilities. We have written in an earlier edition of proposing an International Lunar Geophysical Campaign and that could also be enabled by an E-M L2 project using robotic telepresence for much more extensive and long duration lunar surface exploration rovers augmented by the potential for repair, resupply, and sample return by robotic landers.

The Mars Community can get:

1 Long duration space flight demonstrations of life support needed for a humans to Mars mission.

2 It can also demonstrate a system design that can withstand the radiation environment for long duration space flight. This facility can demonstrate using the mass one has to great shielding advantage such as fuel tanks in an integrated depot.

3 The E-M L2 station is the prototype for a replicated orbital complex system in Mars orbit. It too would have a fueling station that could accept fuel from in situ production from the Martian Moons or the Martian surface. It too would have an manned orbital complex so that affordable telepresence exploration of Mars can occur. It too would have refuel-able landers that could conduct human sortie missions to the for the whole Martian globe. It too would have a safe place of retreat in orbit from the lunar surface if crews had to be evacuated. John Strickland has written in detail about these architectures which have a lunar ferry and Mars ferry capabilities.

4 The build up of Mars infrastructure can in essence begin in parallel with that on the Moon. We design in the beginning things that will be needed in the Mars system and prototype them at E-M L2. **Our Mars program is our E-M L2 program in the sense of a Mercury, Gemini, Apollo evolution of capabilities.** As we build our E-M L2 complex we demonstrate how we can also do this at Mars either by direct replication or in an evolutionary design modification.

Some Intellectual Acknowledgments

Now it would be remiss not to acknowledge the intellectual contributions of researchers such as:

1 Dr. Paul Spudis and Anthony Lavoie in their 2011 paper*

2 Gordon Woodcock in his paper of 2012*

3 John Strickland recent work on lunar and Mars ferries*,

4 Jeff Greason's, (X-Cor President), speech at the 2011 ISDC on the space logistics of ISRU and fueling capabilities, and

5 Dr. Jack Burns and the NLSI Team at the U of Colorado at Boulder who have all done the foundational work in developing these Moon-Mars strategic architecture ideas.

6 Another brilliant group to cite is the Brown University MIT team that has looked at the architecture of returning to Lunar exploration using existing launchers and reported at the Lunar Planetary Science Institute meeting and the NASA Solar System Exploration Research Virtual Institute virtual conference in July 2013.

7 Many of the elements proposed here are also found in the NSS Roadmap, which reflect the work of the NSS Roadmap committee of Jeff Liss, John Strickland, and Bill Gardner who did the heavy lifting as I recall from my time there .

I find the SFF proposal is for the most part a synthesis of many of their ideas as is mine. Some of these papers can be found on the Moon Society web-site*: So this is the way forward in a win-win scenario of multiple dimensions. It think that this is a program that can find ongoing support in the US Congress because it has so many communities that benefit. As an international program it spreads the costs, the risks, and the benefits and builds and expands on the success of the ISS with additional partners.

A GeoPlatform side branch for Communications and SBSP

An additional benefit is that the infrastructure that is put into place for E-M L2 also enables proposals for a potential GEO platform with a market for hundreds of transponders. It would also require substantial solar arrays with deep redundancy to insure that this broadcast complex would function with extreme reliability. It might have large dish structures to capture weak cell phone signals. It's construction would require a supply chain and telepresence operations as well as sophisticated AI capabilities and an enhanced cislunar communications and navigation system. Because this first GEO platform idea is also a tech demonstration it would of necessity have heavy government subsidies but also a substantial blend of commercial satellite support. So much of what the E-M L2 project accomplishes can be amplified with a subsequent GEO platform project.

On the Road to Space Solar Power

Such a platform might also serve as an early prototype for a SSPS. Perhaps this demo SPS subsidy could also be justified by the ongoing need for a transparent mission to provide high cost emergency power in the wake of frequent natural disasters on Earth. There are an endless succession of such disasters among both the rich and the poor nations which we all witness. While they may not be specifically predictable their occurrences are statistically undoubted and the wide scope humanitarian purpose for this demonstration would be an important international justification. Dr. Abdul Kalam has called for a “Space-based Solar For A Livable Earth” Kalam-NSS initiative and this GEO Platform could be an important milestone along that roadmap. A project of this sort would also provide a place and a use for the ISRU for both lunar and asteroidal resources. So the E-M L2 can play a role in that evolution as well with its telepresence capabilities on either the lunar surface or potentially in proximity to a small asteroid and integrate the evolution of ISRU.

The Earth Moon Gateway can also assist in the assembly of Mars mission "stacks" refuel them and send them on their way from L2. Other deep space missions could be similarly enabled as well.

A Strategic Combination of both Capabilities and Destinations

The E-M L-2 Gateway Way Forward is a pragmatic scenario that combines many agendas into a coherent development narrative. It can be supported by many space and industrial constituencies and international partners and investors. This scenario is also one that has some support within NASA and that is hopeful because it is "an inside job" not one that has to be fought for from the outside. NASA Deputy Administrator Lori Garver mentioned this E-M L2 in her speech to the AIAA in the fall of 2012 but it was not "rolled out" as a major Obama administration initiative. Perhaps, the fear was that it would be opposed in a knee jerk reaction by Congressional Republicans engaged in the budget sequester initiative. It is still alive and mentioned in NASA meetings I have attended so perhaps it is best left to simmer as "soup on the US Congressional stove". This “Way Forward soup” has something to offer for supporters on both sides of the aisle as the NASA budget develops and for International participation as well. If the US begins to regain its forward economic momentum in 2014 then perhaps it can reflect that in the arena of space strategy and development outlined above in its 2015 and 2016 budgets.

Time to Fruition

The ISS was proposed in the early 1980's as a follow-on program to the Shuttle, a justification of the construction capabilities of the Shuttle, and a destination for the shuttle and other launchers of the ISS coalition. It wound up taking 30 years to realize this vision with its nominal completion in the summer of 2011. The E-M L2 proposition should be achievable much more quickly than that but it will be a few more years for the pieces to fit into place and I estimate perhaps 13- to 15.

The SLS is not scheduled for first flight until 2017. Orion will also take some more time until perhaps 2021. Commercial Crew capabilities for the Dragon, and CST-100, and Dream Chaser are not expected before 2017 to regain US manned capabilities to LEO. The Falcon 9 Heavy is undergoing its first flight late in 2013 or perhaps slipping to 2014 as these things often do. It has another Air Force launch in 2015 as a second flight. Work on in space refueling has begun on the ISS and that will need time for development. Could we see a LEO depot by 2015? Bigelow is going to demo its inflatables on the ISS so the

evolution of those system will also need some additional time. The Russians should be flying their new Angara rockets in this same time frame and the Indians should have their PSLV LoxHydrogen 2nd stage in operation. Perhaps Korea, Brazil, and Ukraine will have new capabilities by 2020.

Many of these technology pieces will mature during the administration of the President succeeding Obama. It will more probably fall to the President after that to really sell this agenda to both Congress and the International partners. The partisan politics of the present make long term plans and commitments difficult. It is not unreasonable to believe that an E-M L2 program might be realized between 2024 and 2028 with the maturation of many current projects. Politically, because the Chinese will be supplying visible competition with their new space station on a 2020 schedule, a renewed push from the ISS nations will be probable response. A 14 year prediction may seem a long way out but in the context of my lifetime it would be optimistic in comparison to the early proposals to the ISS and its completion. of 30 years. This is also a vision for sustaining and expanding the scope of cislunar space operations and capabilities.

Space Tourism

I have not mentioned until now the impact of space tourism on the next 15 years of space development. That might also accelerate public interest and engagement. Safe if expensive public access to space will also be transformative but this is a high risk market. It only took one accident to kill off the 30 year success of the Concorde which served a high income niche market. Space Tourism will have to bring down its price point so that masses of people experience and support this infrastructure. That mass experience of people experiencing space is also a globally powerful means of transforming political and economic consciousness of the world about the potential and significance of the space economy and of the human potential of the settlement of space.

If this is achieved then I think that Humans can be in the Mars system in another 20 years or so. I do not disagree with that timeline of the SFF. **I try to demonstrate a pathway for the development of space-based solar power** which would also be a powerful driver of private and public capital investment, a program with substantial economic returns to both investors, the global energy economy and the environment as we move forward.

So that is my dueling Way Forward Scenario. I hope I am around long enough to see if my program description is realized for an E-M L2 station. Start your stopwatches but don't try to hold your breath for 14 years! If you are in high school now you may see this by the time you are 30. If you are not that young, and, if you can keep breathing that long, join me in celebrating my 80th birthday so we can also celebrate this achievement together! DD

A Campaign for the International Lunar Geophysical Year: Some Beginning Considerations

By Dave Dunlop, National Space Society

Background

The Proposal for an International Lunar Geophysical Year was first made by Russell Cox of Flexure Engineering, in a presentation at the October 2012 LEAG Meeting at Goddard Space Flight Center. This idea was mentioned en passant as consistent with a cluster of funded lunar missions in the 2017-2018 time frame by the following countries:

China	**Changé V**	2017	A lunar sample return mission (following prior Change III and IV missions beginning in 2013)
Russia	**Lunar Resource**	2017	A lunar sample return mission (following a 2015 lunar lander and orbiter mission.
India	**Chandrayaan II**	2017	
Japan	**Selene II**	2017-2018	

(The ESA-based organization ILEWG [International Lunar Exploration Working Group] has proposed **an International Lunar Robotic Village** for some time. The European Council at about the same time as the LEAG meeting in the fall of 2012 "shelved the Moon Next" lander mission which had been scheduled for 2018 and reduced this to a maintenance level of about $20M annually. This project although not quite dead is now known (to the best of my knowledge) as the European Cargo Lander Program and its survival and reactivation is no doubt tied to the financial fortunes of the European Union economy.)

ILGY Presentations

The International Lunar Geophysical Year was also put forward as an idea of both political, technical, and scientific relevance to both the US economic and political policy malaise affecting funding of new NASA lunar programs. A poster presentation of the ILGY authored by Russell Cox, Dr. Pamela Clark, and David Dunlop at the Lunar and Planetary Institute Science Conference in March 2013 and another by David Dunlop at the International Space Development Conference Lunar Conference in San Diego in May. An article on the ILGY essentially the same as the prior poster was published in the To The Stars International Quarterly electronic publication on the National Space Society web-site and Moon Society web-site in April 2013. Another similar poster was submitted to the Solar System Exploration Research Virtual Institute SSERVI annual forum meeting in July 2013.

<< Note: **Underlining is used below to highlight existing initiatives that might be components of an ILGY Campaign beginning in 2017**.>>

US Space Policy and Lunar Missions

President Obama's priorities involve going first to asteroids and Mars, not a return to the Moon as had been the policy direction of the prior George W Bush administration. The push of funded precursor lunar missions started under the Constellation Program has largely continued with the recent GRAIL mission, the extended LRO mission and the LADEE mission. Despite these impressive and productive missions new lunar missions initiatives have largely been starved for funding.

This ILGY Campaign however would continue over projects spanning perhaps a 5+ year year period due to the long term nature of getting funding approval, and mission development.

It would have a three primary purposes

- To promote study of scientific objectives such as those documented in the NR "Scientific Context of the Exploration of the Moon, the LEAG Roadmap, and list of Strategic Knowledge Gaps identified by the NASA Exploration and Operations Mission Directorate and also listed on the NASA LEAG Web-site.
- To promote the enabling technologies and infrastructures that will reduce the cost of subsequent lunar exploration and development mission that are precursor to other destinations such asteroids and Mars.
- To maintain and strengthen international collaboration with regard to the exploration of the Moon building on the ISS international partnerships and the work of the SECG countries.

More Specific Objectives for An International Lunar Geophysical Year

In response to this political and policy problem working assumptions behind the ILSY are:

A If several of the world's largest space faring agencies already have a focus on a return to the Moon with funded mission projects and announced lunar programs then *momentum can be increased in additional nations by the formation of an explicit International Lunar Geophysical Year Campaign Initiative. In the next 3and a half years collaborative efforts can ramp up this initiative with more nations participating.*

B Even if NASA's primary policy focus is elsewhere there are still important initiatives that can result in significant US achievements during an ILGY.

There is a significant and formidable US lunar community of interest and an ILGY Campaign would provide a coordinating focus: The lunar community of interest includes.

1 NASA personnel throughout the organization that would like to see the US return to the Moon and move its exploration program forward,

2 NASA Centers structure of programs and research of relevance to the Moon,

3 The US University Community (most of which are also part of NASA Space Grant) and

4 The lunar research community that has been connected via the NASA Lunar Science Institute. (This community is visible at the LEAG meetings and the Lunar and Planetary Institute annual Science Conference, and the NLSI (now SSERVI).

5 A number of space advocacy organization such as the National Space Society, Moon Society, and Open Luna also promote a vision of continuing exploration and economic development in and around the Moon in cislunar space.

6 There are still advocates within Congress that support a more vigorous US lunar program. The lobbying and public education outreach activities of the Space Advocacy organizations are still a largely independent voice with regard to US lunar policy.

7 The GLXP initiative of the X-Prize Foundation and the Google Corporation is a noteworthy initiative of significance in the US and globally.

8 The Pacific International Center for Exploration Systems is a state funded organization in Hawaii that can facilities additional international cooperation in lunar exploration and systems development.

9 There are many potential US contractors that would also benefit from a reactivated US lunar campaign.

How the global lunar community of interest might support an International Lunar Geophysical Year Campaign at present.

A The GLXP initiative is also potentially well aligned with a ILGY campaign if the of GLXP teams focus on this objective after 2015. While many GXLP teams are poorly funded with little likelihood of launching a lunar lunar lander-rover mission a few teams may achieve this objective: The most likely seem to be:

- Moon-X in the US which has achieved private funding from a couple of billionaires as well as some NASA collaboration.
- **Astrobotics**, has mounted a substantial design and development campaign with a focus in In Situ lunar resource development payloads.
- **Team Barcelona** which claims to have arranged a launch for its lunar rover on a Chinese long March Rocket
- T**eam Space IL**, a formidable effort in Israel involving Israeli Defense Industries an a number of Universities has utilized a Small CubeSat scale design.
- During 2012- 2013 a number of teams have already consolidated their efforts or have been absorbed by their competitors. The GLXP competition has developed milestones for the competition as the competition enters it last two years. The GLXP is something that has the Google Earth and Google Moon.

B. An International Lunar Geophysical Year Campaign would provide a rationale for continuing lunar mission teams that have developed under the GLXP initiative. It would also provide a transition rationale from a focus on developing lunar lander platforms and rovers to lunar science instruments and payloads more in line with the financial resources of many of the existing teams and also of national space agencies in many smaller countries. The economic meltdown in the US and Europe has constrained the funding raising environment especially in the private sector. **So small national team initiatives funded with a flexible mix of both private and national funds could be an appropriate transitional strategy from initial GLXP rules that limited government participation to only 10%.**

C. Russell Cox used the QB 50 Project as an model of many international participants collaborating with their small cube satellite projects in a larger framework as a model that might apply to a broad base of participation in the ILGY Campaign.

This GLXP constraint on government funding has thus far demonstrated that few such efforts are viable as strickly private initiatives. Only a few of the 25 teams may actually launch something to the Moon by December 31, 2015.

I have discussed this potential for the evolution of the GLXP Teams with Dr. Andrew Barton, Technical Director of the GLXP program at the International Space Development Conference in May. The GLXP teams are potential components of an ILGY Campaign and important potential points of private and public support.

The CubeSat paradigm is one widely shared around the globe in University and government sponsored engineering programs so the transition of the GLXP teams as a foundation for an ILGY Lunar Cube-Hitchhiker network is an important element of the ILGY proposal.

D. The Space Exploration Coordinating Group (SECG) (US is one of 12 cooperating members) released an updated Global Exploration Roadmap in August 2013.which shows a NASA Morpheus lunar mission upcoming in the 2017-2018 time frame. It also reflects a collaborative architecture of exploration between at least NASA, and other international members. The ESA Cargo lander was one element of this coordinated architecture development.

Perhaps an ILGY would encourage a renewed European effort in with regard to the ESA Cargo landers. Continuing SECG discussion may also move forward closer collaboration among those countries with existing lunar surface projects to realize "a functional Robotic Village." **An ILGY Campaign initiative might be integrated into the discussions of the SECG.**

E. An ILGY promoted by the IUGG in Paris might provide a invigorated global lunar community which hopefully might yield a variety of practical results:

- A further spur to the European Union's lunar community and the ESA lander program reactivation as one side benefit.
- It might also spur completion of the European Student Moon Orbiter project by ESA with Surrey Satellite as the lead coordinating company.
- It might also spur space agencies in other countries wishing to participate in a ILGY Campaign to adapt some of the existing GLXP teams and transition their efforts toward more science based purposes.

(The lunar rover development work already undertaken by many of these teams might well apply to the delivery of small instruments across the lunar surface as secondary payloads.)

While the GLXP competition is scheduled to end in 2015 new ILGY teams might also be organized within the context of a Lunar Cube-Lab Hitchhiker paradigm and directed toward commercial lunar landers as a platform for development.

F. Prize Incentives

The GLXP might be repurposed at the end of 2015 so that the team network is both continued and expanded to create a ILGY Teams Lunar Exploration Network. Prizes might be offered in certain technology development areas. The NASA Millennial Prize Program is one component of this interest. The X-Prize foundation is another established private venue.

The ILGY Campaign could provide a coordination context for both the NASA Millennium as well as the X-Prize and Google organizations in advancing both technology and its commercialization in the challenging environments of the Moon. Suggested incentives include: Cryogenic Engineering Prizes

1 **Cryogenic Engineering Prizes**

The Moon is both the coldest place known in the solar system and also the closest and cheapest place to develop and test and demonstrate cryogenic engineering in a natural environment.

2 In Situ Resource Demonstration Prizes

Moon-X, one of the leading GLSP teams has commercial ambitions for both lunar transportation services as well as In Situ Resource Development. This lead by CEO Dr. Bob Richards.

It now has commercial competitors such as Deep Space Industries lead by CEO David Gump, and Planetary Resources that focus on In Situ Space Resources Development lead by CEO Chris Lewicki.

Prize(s) for such demonstrations would spur continuing interest among both the ge public but also the investment community at large which looks to such missions as buying down the risk for future commercial initiatives.

3 Lunar Surface Energy System Demonstrations Prizes

The demonstration of the sun's energy as a sustaining system on the lunar surface is needed. Prizes could be offered for the development of lunar energy utilization systems that can incorporate:

- Solar energy generation which can withstand the day-night cycle.
- Solar Energy storage which accommodates the lunar day night cycle, and the associated temperature cycle.
- The transmission of energy by laser system across the lunar surface and into lunar cold traps for both mobile and stationary equipment operations.
- The use, servicing and retirement of RTG technologies on the lunar surface

4 Lunar Commercial Market Development Contract Awards for new lunar related business start-ups

There are many business plan start-up initiatives such as those by Space Frontier Foundation, Space Resources Roundtable, and other groups but few that provide a game changing enterprise. NASA could provide additional commercial contract awards in order provide an incentive for entrepreneurial investments for cislunar infrastructure like a cislunar satellite positioning system, or a system of space fueling depots that meet the in space refueling requirement needs of international launchers, or a solar electric propulsion driven reusable in-space tug that could demonstrate the feasibility of extending the supply chain to GEO, and the E-M Lagrange points. These would provide a " capital incentive" target for commercial satellite and transportation technology companies.

This could also provide a synergistic effect with NASA SBIR and TTR space commercialization funding. It could also be coordinated with the new NASA Space Technology Mission Directorate as part of the game changing technology development initiatives.

G. Human Lunar Return Commercial Development is a potential market for Lunar ISRU. Alan Stern is also leading an initiative to development Lunar Expeditions as CEO of the Golden Spike Company.

Bigelow is another company that has ambitions to provide commercial habitation on the lunar surface. Shackleton Industries is another firm led by Jim Keravala that also had commercial development ambitions on the lunar surface. There are potential synergies between large scale commercial organizations and and much smaller robotic precursor commercial initiatives.

H. Lunar payloads list might be established by LEAG to encourage and track both science and commercial lunar payload ideas and projects which advance the LEAG Roadmap and Strategic Knowledge Gaps goals and to track and facilitate the rides to the Moon available from both Commercial and Government Organizations.

I. An ILGY Campaign is also consistent with the technology evolution that is underway with regard to the capabilities of cube satellites. Russell Cox has focused much of his attention on the "Lunar Cube Paradigm" also termed "Lunar Hitchhiker" for the potential launch of these small missions as secondary payloads on commercial missions. Such small spacecraft especially launched as low cost secondary payloads might perform useful science in cislunar space. He is not alone in pursuing this vision. An ILGY Campaign would serve to accelerate interest and funding support for several existing cislunar projects not connected to the GLXP:

- A Lunar Swirls Orbiter and Impactor Mission being developed by Ian Garrick Bethel at the University of California Santa Cruz in collaboration with UC Berkeley **NASA AMES**, and Kyung Hee University in S Korea with some KARA support.
- A Lunar Cube Initiative at the Vermont Technical College by Dr. Carl Brandon with collaboration from the Vermont Space Grant Consortium, **Goddard SFC**, and **JPL**.
- A Cube-sat Initiative at Baylor University by Dr. Rene Laufer in conjunction with University of Texas at Austin to flight test a dust particle detector on a NASA and USAF funded projects with two cube sat launches scheduled for 2014.

This list may not be exhaustive of current initiatives.

J. Lunar Cube Hitchhiker as a Technology Trend

- Two Interplanetary CubeSat Conferences have been organized in 2012 and 2013 at MIT and Cornell respectively.
- Lunar Superconducting Conferences have been held organized by Russell Cox of Flexure Engineering and the University of Houston Superconducting Center in 2011, 2012. Several follow-up workshops have been held in 2013.
- The International Astronautical Conference has also had Lunar Hitchhiker Sessions in 2011, 2012, and scheduled for the 2013 Beijing under the Chairmanship of Dr. Rene Laufer.

A Lunar Hitchhiker study group is being organized by Dr. Rene Laufer, of Baylor University, Dr. Leon Alkali, and Amanda Stiles (now with Space X) for the purpose of making a two year study of the potential use and development of the Lunar Cube Hitchhiker paradigm. I have been invited to participate in this group by Dr. Laufer as has Dr. Pamela Clark)

The ILGY Campaign should be presented in the context of this technology trend at these ongoing conferences as a public policy and international science initiative that can be advanced by this new Lunar Cube Hitchhiker technology development as well as by the improved coordination of existing initiatives.

K. Some NASA Lunar Initiatives that might play a key role in an ILGY Campaign

NASA's newly organized Space Technology Mission Directorate has a number of technology initiatives directly pertinent to extending the capabilities of Cube scale spacecraft.

These include:

- Optical Laser communications development,
- Small atomic clock development,
- Solar electric propulsion systems including :
  - √ A magnetically shielded Hall thruster,
  - √ Power Processing Units,
- Solar sails and deployment mechanisms.
- A Green Propellant 22 Newton ion thruster to replace Hydrazine thrusters,

These budgeted technology development programs may offer additional opportunities to test in space and reach the Moon. A test in space philosophy for these technologies can also provide affordable opportunities for a new series of demonstration and test missions in cislunar space as well as to the lunar surface. The FY 2014 STMD Small Spacecraft Technology Program. Is budgeted for $17M.

Demonstration missions are budgeted for $282M. The Game Changing Technology Program is budgeted for $76M. Both NASA and the DOD have cube sat launch competition opportunities programs.

NASA JSC has a Morpheus Lunar Lander with an 1100 lb surface payload capacity technology development program with both LOX-Methane propulsion engines and a Landing hazard avoidance technology program. NASA Exploration and Operation MD has a Lunar ISRU payload project under development in the ISRU program associated with this mission.

LEAG could strongly endorse NASA's moving forward with this lunar surface mission and also determine how other small science instrument packages might ride along.

NASA has a Night Rover Millennium Challenge to advance battery technology under conditions similar to the lunar temperature cycle. This might provide yet another another technology development initiative that could be tested on the lunar surface.

The NASA Lunar Science Institute now renamed the Solar System Exploration Research Virtual Institute has a network of international collaborative country teams that might also be play a role with regard to an ILGeophysical Year Campaign. These international nodes have their own national funding sources. They as an already connected network could also provide a basis for new ideas and support for an ILGY from their countries.

L. Non-NASA Initiatives

- The Pacific International Center for Exploration Initiatives (formerly the International Lunar Research Park) in Hilo, Hawaii is a state funded initiative with strong international connections with Japan, the CSA, German Space Agency, as well as NASA. This program can provide analog environment mission testing as part of an ILGY Campaign.
- The prior International Geophysical Year and Polar Years have been organized under the auspices of the International Union Geodesy and Geophysics organization. A significant step is to approach IUGG with this proposal with the sponsorship of recognized international planetary scientists.

Summary

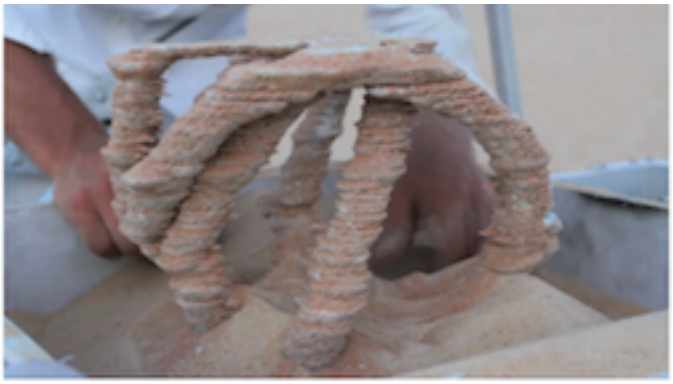
The ILGY campaign proposal is an effort to develop a international scientific campaign repeating the success of the International Geophysical Year and other subsequent polar year collaborations but targeting the Moon in a coordinated international scientific campaign. It is also intended as a campaign to support both the infrastructure development and the technology development which will enable advancement of lunar exploration and the economic utilization of the Moon in a way consistent with the Global Exploration Roadmap developed by the Space Exploration Coordinating Group of Nations. **DD**

A Model for Early 3-D Printer Production on the Moon - VIDEO

Sent by Nelson Bridwell to the Moon Society Facebook page

http://vimeo.com/25401444

"In this experiment, sunlight and sand are used as energy and raw material to produce glass objects using a 3-D printing process that combines natural energy and material with high-tech production technology." This experiment was done in the Sahara Desert near Siwa. Egypt. "This might be a good fit for manufacturing heavy structural components on the Moon, lowering the cost of lunar development. Perhaps the generated gasses could also be captured and put to constructive use."



http://www.Moonsociety.org/publications/mmm_themes/mmmt_LunarEconomy.pdf (227 pages)

International Space Advocacy Organizations Encouraging Student Participation

National Space Society (US) – http://www.nss.org – **NSS**
NSS currently has chapters in Australia (3), Canada, Germany, France, Netherlands, Brazil, and India (3) – http://chapters.nss.org/a/lists/

NSS' International Space Development Conference
The "ISDC" is usually held the last 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.

The Moon Society – http://www.moonsociety.org/chapters/ – 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 Quartely, has been going to students and ohters in India and Elsewhere since August 2008. Older issues are available as free pdf downloads at: http://www.moonsociety.org/india/mmm-india/

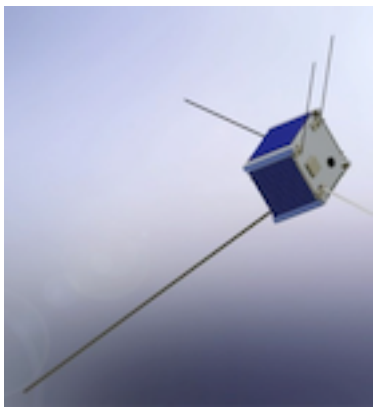
Students for the Exploration and Development of Space – SEDS
http://www.seds.org
SEDS has had greater success in setting up chapters around the World than any other Space organization.
How to Stars a SEDS Chapter – http://wiki.seds.org/index.php?title=Start_a_SEDS_Chapter
http://seds.org/chair/ChapterExpansionKit30.pdf
SEDS-Earth – http://earth.seds.org/index.php – This is the international chapter.
There are chapters of SEDS around the world: (USA), **India, Nigeria, UK, Philippines**, and more; SEDS-Earth is a central node for communication between these worldwide chapters.
SEE page 2-3 for a more complete list

Lithuanian Students Hope for free Launch of 2 Amateur Radio CubeSats

http://www.arrl.org/news/view/lithuania-looks-to-launch-amateur-radio-cubesats
07/02/2013 Lithuanian students hope that that country's first two satellites will be launched later this year from the International Space Station (ISS). The nanosatellites carrying Amateur Radio payloads "could be" among the CubeSats sent by payload handler NanoRacks LLC to ISS on SpaceX CRS-3 November mission.

The **Kaunas University of Technology** is developing LituanicaSAT-1l which will carry a VGA camera, GPS receiver, 9600 bps AX25 FSK telemetry beacon and a 150 mW V/U FM voice transponder.

while the **Lithuanian Space Association** is working on LitSat-1, which will have a U/V linear transponder for SSB/CW communications.



Left: LituanicaSAT-1 **Right:** LitSat-1 and crew ##

NASA Selects 7 University Projects For 2014 X-Hab Innovation Challenge

http://www.spacedaily.com/reports/prnewswire-space-news.html?doc=201307081605PR_NEWS_USPR____DC43828&showRelease=1&dir=0&categories=AEROSPACE-AND-SPACE-EXPLORATION&andorquestion=OR&&passDir=0,1,2,3,4,5,6,15,17,34

WASHINGTON, July 8, 2013 /PRNewswire-USNewswire/ -- NASA and the National Space Grant Foundation have selected seven projects from six universities to participate in the 2014 Exploration Habitat (X-Hab) Academic Innovation Challenge.

- Oklahoma State University Stillwater: **Horizontal Habitability Layout Studies**
- University of Colorado at Boulder: **Plant Anywhere: Plants Growing in Free Habitat Spaces**
- Rice University, Houston: **SpaceRing: a Versatile, Scalable Power-Generation and Cooling System**
- University of South Alabama, **Mobile: Closed Environment Air Revitalization System Based on Metal Organic Framework Adsorbents**
- Univ. of Wisconsin, Madison: **Badger Compartmentalized Onboard Material Extrusion Technology**
- University of Maryland, College Park: **Vertical Habitability Layout Studies**
- University of Maryland, College Park: **Neutral Buoyancy/Parabolic Flight Habitat Studies**

The undergraduate student teams must meet a series of milestones to design, manufacture, assemble and test systems and concepts that could be used in future deep-space habitats. The National Space Grant Foundation will fund design costs, development and delivery of the systems to the AES Deep Space Habitat Project team in mid-2014.

http://www.spacegrant.org/xhab

http://go.nasa.gov/11nXhlTs"

For information about the Advanced Exploration System Program Deep Space Habitat Project team, visit:

http://go.nasa.gov/L37Ymq

Penn State University "Lions" take on the Google Lunar X-Prize Challenge

https://www.gingrichproductions.com/2013/06/**lions-on-the-moon**/

About the Google Lunar X-Prize

Google is sponsoring this prize through the XPRIZE Foundation, which, in 2004, awarded $10 million to the team behind SpaceShipOne, the first private human spaceflight vehicle.

Twenty-three private initiatives around the world, including 7 led by American teams, are working to land robotic spacecraft on the Moon once again – with minimal government funding.

The teams are competing to win the Google Lunar XPRIZE, which will award $20 million, plus up to $10 million in bonus prizes, to the first group to successfully land a robot on the Moon, beam high definition video back to Earth, and travel 500 meters.

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The best part is that although there are now 23 projects working to send robots to the moon, Google won't spend anything until one of them is successful. The prize model, around which most of our efforts in space should be restructured, ensures that you pay for the achievement, not for the effort.

Amidst this resurgence in the space industry, there is a shining example that combines exploration with education. Penn State University is pursuing Google's prize with a group of students and researchers called the Lunar Lion team. The team's design has taken a unique and interesting approach.

About the Penn State Lunar Lions Team

The Penn State Lunar Lion Team is a combination of Penn State students and faculty combined with engineers from Penn State's Applied Research Laboratory. To fulfill the requirements of the Google Lunar X Prize, the team draws on the university's extensive expertise in electrical, mechanical and aerospace engineering and its experience in drafting, fabrication, assembly and testing.

The team is pursuing partnerships with companies throughout the aerospace industry to strengthen the project. Their philosophy is one of simplicity – assembling the minimum number of systems in the shortest possible time.

A single machine, the Lunar Lion, serves as spacecraft, lander and rover.

A commercial launch vehicle will inject the Lunar Lion on to its trajectory to the Moon where the Lion's main engine will place the vehicle on a direct approach to the Moon, and then provide the thrust for course corrections and landing. After touchdown and transmission of the first "mooncast" report, the Lion's engine will lift the vehicle into a low flight path to a second landing 500 meters (547 yards) away.

http://www.googlelunarxprize.org/teams/**penn-state-lunar-lion-team**

The team brings together students and faculty as well as engineers from Penn State's Applied Research Laboratory. Penn State has extensive expertise in electrical, mechanical and aerospace engineering, including experience in drafting, fabrication, assembly and testing.

Do you experience "Manhattan Henge" in your home town?

http://www.space.com/21947-**manhattanhenge-new-york-s-magic-sunset**.html (Video)

http://www.ibtimes.com/**what-manhattanhenge**-707889

Advanced Robot with more sophisticated motion capabilities unveiled

http://www.space.com/21976-**advanced-humanoid-atlas-robot-is-unveiled-video**.html

The Ongoing CubeSat Revolution: what it means for Student Space Science

List of cube sat articles this issue – prices – piggyback launches

By Peter Kokh and David Dunlop

ISS "launches" other "piggyback" opportunities

first and current "cell phones," computers, laptops, and more. A revolution that is only in its "teen" stage.

http://www.nbcnews.com/technology/**scientists-design-3-d-printed-satellite**-1C7265444

Do you Have a Telescope to look at the Moon, Mars, and the Stars?

How would you design an amateur telescope for use on the Moon, that you could use without putting on a clumsy spacesuit and helmet?

Twenty-five years ago, in 1988, Moon Miners' Manifesto put that question to readers and members of the Milwaukee Lunar Reclamation Society (NSS chapter) and of The American Lunar Society.

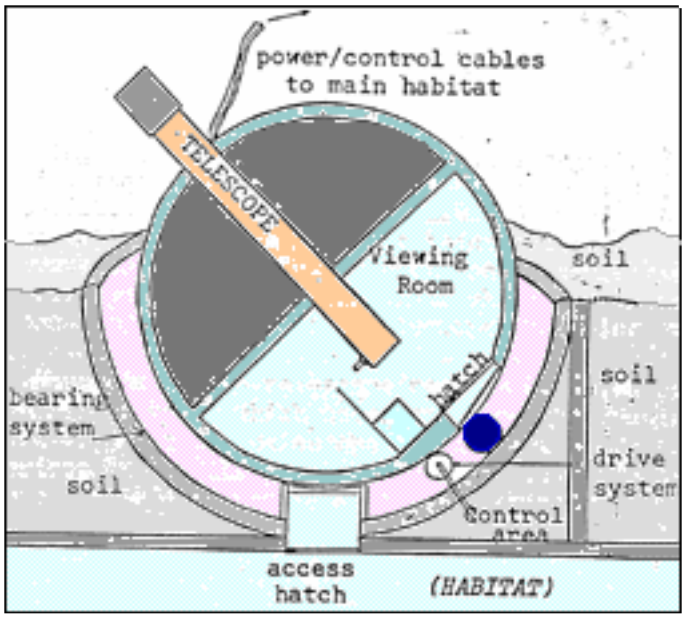
[* Electronic ways to channel a telescope image" from a scope on the surface to a comfortable viewing area within a pressurized habitat were not admissible in this "engineering" exercise]

Below is the winning design {coloration added by editor]

AN AMATEUR LUNAR TELESCOPE DESIGN

By Peter Kokh

Design contest restriction: "electronic ways to channel a telescope image" from a scope on the surface to a comfortable viewing area within a pressurized habitat were not admissible in this "engineering" exercise.



Submitted by Milwaukee School of Engineering (MSOE) student and MLRS member Ron August of Hubertus, Wisconsin, US, this ingenious concept involves a moving, spherical shaped "viewing room," with the telescope an integral part of it, that is completely pressurized, heated, and accessible from the Moondust-shielded habitat below. Entrance to the room is by way of an airtight access hatch system.

Once inside the viewing room, the observer will be strapped into a viewing chair which has all controls for movement of the telescope (and viewing room) and focusing of the telescope.

Movement of the telescope/room is achieved by a controller wheel which moves the room into position to point the telescope at anything above the horizon in all directions. The room is suspended by a low friction smooth-running bearing system.

This was the winning design in a competition cosponsored by MLRS and the American Lunar Society. Two other entries received honorable mention, including one in which a zenith-pointing telescope had its base within the habitat, the shaft piercing the regolith shielding overburden and open to the vacuum. The scope turned in a sleeve using a barometric liquid seal and surface mirrors to redirect the view.

How future settlers on the Moon and/or Mars will pursue their amateur astronomy hobby is not an idle question! Fascination with the stars and the heavens is deeply rooted in human history, and as we slowly move beyond Earth, and eventually "to the stars" that fascination, curiosity, and wonder, will only go stronger.

If you are an amateur astronomer and/or belong to an amateur astronomy club, why not look at the design challenge from scrap and submit your own design? Send to kokhmmm@aol.com ***

Archaeological Preserve in New Mexico, USA, Named New Dark-Sky Park

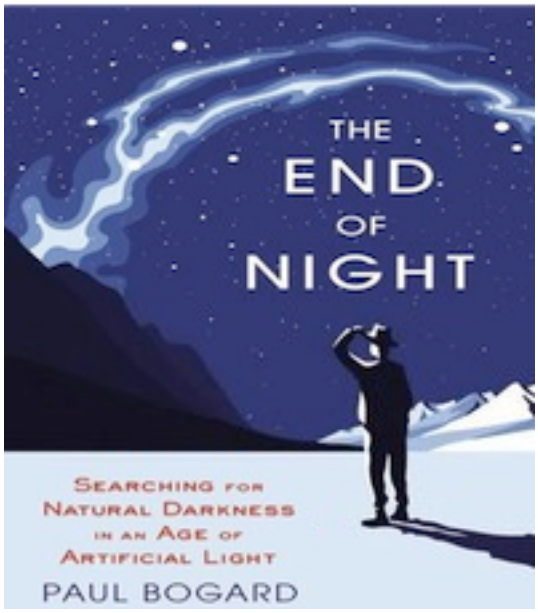
August 29, 2013 - **http://www.space.rcom/22583-chaco-new-dark-sky-park**.html
http://en.wikipedia.org/wiki/Chaco_Culture_National_Historical_Park
A Great Student Project: Campaign for establishment of "Dark Sky Preserves/Parks" in your Country

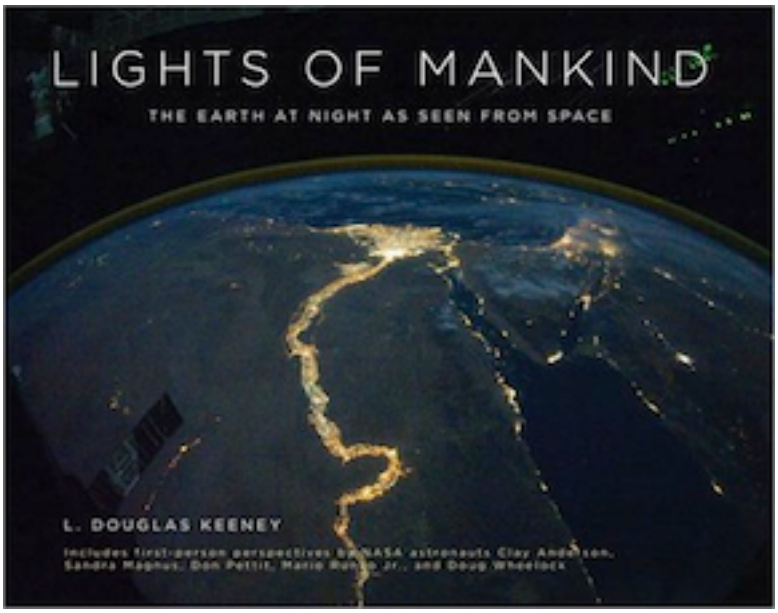
The **Chaco Culture National Historical Park** has just been designated a Dark Sky Park.

Free of light pollution, the archaeological site in northwestern New Mexico offers amazing views of the night sky, such as this view of the Milky Way. (link below)

http://i.space.com/images/i/000/032/257/i02/Milky_Way_Fajada_Butte_full.jpg?1377783684

On this topic: Light pollution makes it increasingly difficult for people to truly appreciate the night sky. Jeff Foust reviews a book where the author travels across two continents seeking dark skies and a better appreciation of the night. www.thespacereview.com/article/2354/1





Also: "**Lights of Mankind**" - The Space Review, Dec. 12, 2011 - www.thespacereview.com/article/1986/1

Mars Society's International Student Design Competition: Inspiration Mars

Mars Society Announcement August 22, 2013

The Mars Society released today additional information, including rules and regulations, about the recently announced **international student contest to assist Inspiration Mars with the design of its planned Mars fly-by mission.**

http://www.marssociety.org/home/press/announcements/marssocietylaunchesinternationalstudentdesigncompetitionstudentstoproposedesignconceptsforinspirationmarsmission

Moon Miners' Manifesto Resources

http://www.moonsociety.org/chapters/milwaukee/mmm/

MMM is published 10 times a year (except January and July. The December 2011 issue began its 26th year of continuous publication.

Most issues deal with the **opening of the Lunar frontier**, suggesting how pioneers can make best use of **local resources** and learn to **make themselves at home.** This will involve psychological, social, and physiological adjustment**.**

Some of the points made will relate specifically to **pioneer life** in the lunar environment. But much of what will hold for the Moon, will also hold true for **Mars and for space in general.** We have one Mars theme issue each year, and occasionally **other space destinations** are discussed: the asteroids, Europa (Jupiter), Titan (Saturn), even the cloud tops of Venus.

Issues #145 (May 2001) forward through current are as pdf file downloads with a Moon Society username and password. Moon Society International memberships are $35 US; $20 students, seniors – join online at:

http://www.moonsociety.org/register/

MMM Classics: All the "non-time-sensitive editorials and articles from past issues of MMM have been re-edited and republished in pdf files, one per publication year. A 3-year plus lag is kept between the MMM Classic volumes and the current issue. **As of December 2011, the first twenty-two years of MMM, 200 issues, will be preserved in this directory,** These issues are freely accessible to all, no username or password needed, at:

www.moonsocietyorg/publications/mmm_classics/

MMM Classic Theme Issues: introduced a new series to collect the same material as in the Classics, but this time organized by theme. The first MMM Classic Theme issue gathers all the **Mars** theme articles from years 1-10 in one pdf file. A second pdf file collects all the Mars Theme issues from year 11-20. The 2nd Classic Theme is "**Eden on Luna**," addressing environmental issues underlying lunar settlement. **Asteroids**, **Tourism, Research**, **Select Editorials, and Analog Programs** have been added. New Theme Issues will be coming: Lunar Building Materials, The Lunar Economy, The Lunar Homestead, Modular Architecture, Modular Biospherics, Frontier Arts & Crafts, Frontier Sports, Other Solar System Destinations, and so on.

www.moonsociety.org/publications/mmm_themes/

MMM Glossary: The publishers of MMM, the Lunar Reclamation Society, has published a new Glossary of "MMM-Speak: new words and old words with new meaning" as used in Moon Miners' Manifesto.

www.moonsociety.org/publications/m3glossary.html

The initial addition includes over 300 entries, many with illustrations. Additional entries are under construction. It is hoped that new members will consider this to be a "Read Me First" guide, not just to Moon Miners' Manifesto, but to our vision and goals.

We insist on capitalizing "Moon" when it refers to Earth's satellite. Read why:
http://www.moonsociety.org/info/capiltal-M-for-Moon.html

All of these resources are available online or as free access downloads to readers.
But TTSIQ does need your help!

To The Stars International Quarterly Advisors, Liaisons, Contributors, Reporters, Illustrators

If this publication is to help spread the word about Space throughout the world, among the public at large, especially among the students and younger people, it must become a truly Indian publication. We need people from many fields in many countries to join our team

If you think that you can add to the usefulness and vitality of this publication, in any of the ways listed above, or in fields we had not thought of, write us at: ttsiq@moonsociety.org [email address reaches the whole editorial team]

Tell us about yourself; your interest in space, and how you think you can make this publication of real service in the education of the public in your country and in the education of young people on whom the future of the world will rest.

Guidelines for Submissions TTSIQ is intended for wide public distribution to encourage support for space research and exploration and development. TTSIQ is not a scholarly review or a technical journal for professional distribution. Submissions should be short, no more than a few thousand words. Longer pieces may be serialized editorials and commentary, reports on actual developments and proposals, glimpses of life on the future space frontier, etc. Articles about launch vehicles, launch facilities, space destinations such as Earth Orbit, The Moon, Mars, the asteroids, and beyond, challenges such as dealing with moondust, radiation, reduced gravity, and more.

Help Circulate To The Stars International Quarterly

If you know someone who might enjoy reading this publication, send us their email address(es) so that they receive notice when each new issue is published. Readers are encouraged to share and to distribute these issues widely, either as email attachments, or via the direct download address (for all issues): http://www.nss.org/**tothestars**/

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To The Stars International Quarterly #5

Engage! And Enjoy!