There is no point in sending humans to Mars, if on arrival, they are too weak to “hit the ground running”

INDEX
2 Co-sponsoring Organizations

NEWS SECTION pp. 3–106
3–24 Earth Orbit and Mission to Planet Earth
25–38 Cislunar Space and the Moon
39–40 Space Tourism (New Section, starting this issue)
41–62 Mars
63–70 Asteroids & Comets
71–87 Other Planets & their moons
88–106 Starbound

ARTICLES & EDITORIALS pp.108–128
108 Early Supporters of Manned Mars Missions Addressed the Risks Involved: – Peter Kokh
  Wanted Split personality types for Mars Expeditions – Peter Kokh
110 Mars Gravity en route to Mars – Peter Kokh
112 Artificial Gravity enroute to Mars and back strongly advised – Peter Kokh
113 NASA’s Timid record on Demonstration of Artificial Gravity in Space – Peter Kokh
114 Avoiding “Cabin Fever” on Moon and Mars – Peter Kokh
120 The Case of Cislunar Cubesats – Dave Dunlop & AL Anzaldua
123 Lunar CubeSat Projects, Mission Proposals, and Technologies – Dave Dunlop
125 After Russia Leaves the International Space Station – Dave Dunlop
126 Online Op–Ed articles from other Writers worth reading

STUDENTS & TEACHERS pp. 129–136
137 Recent Feature Articles in Our Sister Publications: Ad Astra; Moon Miners’ Manifesto
138 About this issue: Peter Kokh
About The National Space Society - http://www.nss.org/
The National Space Society was formed in March, 1987 by the merger of the former L5 Society and National Space institute. NSS has an extensive chapter network in the United States and a number of international chapters in Europe, Asia, and Australia. NSS hosts the annual International Space Development Conference in May each year at varying locations. NSS publishes Ad Astra magazine quarterly. NSS actively tries to influence US Space Policy.

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

About Space Renaissance Initiative – http://www.spacerenaissance.org/
SRI’s focus is on use of space resources to address the challenges of runaway population growth and increasing use of Earth resources at a non-sustainable pace. “The settlement of space would benefit all of humanity by opening a new frontier, energizing our society, providing room and resources for the growth of the human race without despoothing Earth, and creating a lifeboat for humanity that could survive even a planet-wide catastrophe.”

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

About Open Luna Foundation – http://openluna.org/missions
The OpenLuna Foundation aims to return to the moon through private enterprise. A stepped program of robotic missions, then a short series of manned missions to construct a small, approximately 8 person outpost .

About SEDS: Students for the Exploration and Development of Space – http://www.seds.org/
SEDS is an independent, student–based organization which promotes the exploration and development of space by educating people about the benefits of space, through a network of interested students, providing an opportunity

MMM, has been published 10 times a year since issue #1 December 1986 by the Milwaukee Lunar Reclamation Society chapter of the National Space Society. It has also served the Moon Society and its predecessor, Artemis Society International, since October 1995.
Most issues deal with the opening of the Lunar frontier, suggesting how pioneers can make best use of local resources and learn to make themselves at home. This will involve psychological, social, and physiological adjustment. Much of what will hold for the Moon, will also hold true for Mars and for space in general. There is one Mars theme issue each year, and occasionally other space destinations are discussed: the asteroids, Europa (Jupiter), Titan (Saturn), even the cloud tops of Venus, and interstellar destinations beyond.

This and past issues are online at: www.moonsociety.org/international/ttsiq/ and www.nss.org/tothestars/
China’s new Hainan Island spaceport to launch country’s largest rocket yet


China’s huge new Long March 5 rocket will make its maiden flight from its nearly-complete Wenchang Launch Center on Hainan Island, at the southern tip of China.

**Wenchang, Blue water spaceport**

The island, occasionally referred to as "China’s Hawaii," is well-suited for a space port in the relatively undeveloped northeastern corner of the island where Wenchang city planners are working hard to integrate the space port into the island’s tourist offerings. The spaceport will be surrounded by 37 different development projects, including a space-related theme park.

The sprawling spaceport will support China’s space station program, while also boosting the nation’s plans for interplanetary exploration, including human visits to the Moon. The new series of wider-bodied rockets will be launched from there.

**Pushing up against deadlines**

The launch of the Long March 5 series will allow for the orbiting of the Tiangong-2 spacelab, which is slated to go up in 2015.

The booster will be an essential vehicle for the planned Chinese space station, sometimes referred to a Tiangong-3, and necessary for the next generation of Chinese all-weather, high-resolution observation satellites, likely much larger than the Ziyuan series.

The development timeframe of the 5.3 meter wide Long March 5 is pushing up against deadlines for the projected launch in 2015 of the Tiangong-2 and China’s 2020 space station.

The new launch site will free China’s space program from the restrictions of the curvature of rail lines and narrow width of train tunnels. ##

**SpaceX Tests Steerable Fins On Reusable Rocket Flight | Video**

NASA Signs Agreement with SpaceX for Use of Historic Launch Pad

April 15, 2014 RELEASE 14–107 – NASA Kennedy Space Center’s historic Launch Complex 39A, the site from which numerous Apollo and space shuttle missions began, is beginning a new mission as a commercial launch site.

NASA signed a property agreement with Space Exploration Technologies Corporation (SpaceX) of Hawthorne, Calif., on Monday for use and occupancy of the seaside complex along Florida’s central east coast. It will serve as a platform for SpaceX to support their commercial launch activities.

Under a 20-year agreement, SpaceX will operate and maintain the facility at its own expense.

UK Takes Aim at Commercial Spaceflight, Spaceport Possible by 2018

June 1, 2014 – The United Kingdom could have a spaceport by 2018. Government officials hope this will be the start of commercial spaceflight for the country.

There is recognition of the scale of the challenge inherent in identifying, approving and building a U.K. spaceport and in supporting all the necessary innovation and technology that it would require. The U.K. Space Agency, created in 2010, funded a study into spaceport candidate locations, concluding that Lossiemouth in Scotland would be the best site.

Located in northern Scotland, Lossiemouth is on the coast of the North Sea and has a Royal Air Force base with a runway suitable for the types of launch systems that Sir Richard Branson’s Virgin Galactic uses. A September referendum on whether Scotland will remain a part of the United Kingdom could complicate that choice, however.

The Skylon concept vehicle consists of a slender fuselage containing propellant tankage and payload bay, with delta wings attached midway along the fuselage carrying the SABRE engines in axisymmetric nacelles on the wingtips. The vehicle takes off and lands horizontally on its own undercarriage.

The NSTP is producing a technical feasibility study for the 2018 spaceport. Other recommendations in the government’s response include increasing NSTP funding, reducing fees and red tape so new space companies have fewer obstacles, increasing the number of U.K. people in senior positions at the European Space Agency (ESA) — to promote the use of private–public partnerships in ESA programs, ensuring the U.K. makes the most of opportunities under the European Union’s 12 billion euro ($16 billion) 2014–2020 space research funding, and increasing bilateral science projects with other nations. The government will also set up a satellite signal spectrum group.

ROCKET TECHNOLOGY

Morpheus Lander flies again on Green Fuel

NASA’s prototype planet–lander ascended to 800 ft and moved forward 1300 ft on Apr. 2, 2014. The vehicle is fueled by methane and oxygen. Project Morpheus has moved well past its 2012 crash landing.
SpaceX Claims Milestone With Reusable Rocket Test

April 18, 2014 – SpaceX's bold plan to return a rocket to Earth after a space launch on April 18th may not have gone perfectly, but founder Elon Musk still considers it a step towards future fully reusable rockets. SpaceX attempted to guide the first stage of its Falcon 9 rocket back to Earth in an ocean splashdown during the launch of the company's third successful Dragon cargo capsule to the Space Station.

It's still unclear if the rocket stage — outfitted with landing legs — touched down softly as hoped, but billionaire SpaceX founder Elon Musk thinks the odds aren't good, given the 4-6 m (13-20 ft) wave heights. The retrieval boats weren't able to get close because of those heavy seas.

But there were some notable successes regardless of what ultimately happened to the rocket stage. Musk considers the attempt a success in that they were able to control the boost stage to a zero roll rate which is what previously destroyed the stage. The goal is to land rocket stages back on Earth in order to use them again on other spaceflights. Reusable rocket first stages would save a lot of money for both spaceflight companies and space agencies in the future.

Standard Falcon 9 rocket launches now cost somewhere from $50 to $60 million. However, Musk has predicted that a reusable rocket program could reduce capital costs of the rocket to $50,000 if it is reused 1,000 times: the goal to strive for.

"Even though we probably won't get the stage back, I think we're really starting to connect the dots of what's needed," Musk said. "There are just only a few more steps that need to be there to have it all work. I think that we've got a decent chance of bringing a stage back this year [2014], which would be wonderful."

Earlier SpaceX attempts to bring a rocket stage back to Earth in a controlled fashion failed because the rocket's thrusters were unable to overcome its rolling. This time, however, SpaceX added more powerful thrusters and more propellant and it seems to have improved results.

A SpaceX plane collected data as the rocket stage made its way back toward Earth. Once that data comes in, SpaceX representatives will have a better sense of what happened with the test.

This launch also helped SpaceX engineers and representatives demonstrate that the landing legs attached to the Falcon 9 did not have any negative impact during the ascent phase of the flight.

SpaceX's Reusable Rocket Soars to 1,000 m (3,300 Ft) – Lands Safely (Video)

May 8, 2014 – "During the May 1 test flight, the Falcon 9R took off with its landing legs extended. In future tests of the rocket, the legs will lie against the side of the rocket initially, then deploy in time for landing.

"SpaceX is developing reusable rockets in an attempt to dramatically reduce the costs of launching satellites and people into space. Fully and rapidly reusable launch vehicles could make spaceflight 100 times cheaper, company founder and Elon Musk has said."
Such rockets could help make a Mars colony much more feasible — a big priority for Musk, who has said that he started SpaceX primarily to make humanity a multiplanet species.”

NASA Signs Agreement with SpaceX for Use of Historic Launch Pad


April 15, 2014 RELEASE 14–107 – NASA Kennedy Space Center’s historic Launch Complex 39A, the site from which numerous Apollo and space shuttle missions began, is beginning a new mission as a commercial launch site. NASA signed a property agreement with Space Exploration Technologies Corporation (SpaceX) of Hawthorne, Calif., on Monday for use and occupancy of the seaside complex along Florida’s central east coast. It will serve as a platform for SpaceX to support their commercial launch activities.

SpaceX will use pad 39A at Kennedy. About a mile away on pad 39B, NASA is preparing for deep space missions to an asteroid and eventually Mars. “The parallel pads at Kennedy perfectly exemplify NASA’s parallel path for human spaceflight exploration -- U.S. commercial companies providing access to low–Earth orbit and NASA deep space exploration missions at the same time.”

Under a 20-year agreement, SpaceX will operate and maintain the facility at its own expense. SpaceX is the world’s fastest growing launch services provider, with nearly 50 missions on manifest, SpaceX will maximize the use of pad 39A to the benefit of both the commercial launch industry as well as US taxpayers.

The reuse of pad 39A is part of NASA’s work to transform the Kennedy Space Center into a 21st century launch complex capable of supporting both government and commercial users. Launch Complex 39A originally was designed to support NASA’s Apollo Program and later modified to support the Space Shuttle Program. Because of the transition from the shuttle program to NASA’s Space Launch System and Orion programs, the agency does not have a need for the complex to support future missions.

Pad 39A was first used to launch Apollo 4 on Nov. 9, 1967; it is the site where Apollo 11 lifted off from on the first manned moon landing in 1969; and the pad was last used for space shuttle Atlantis' launch to the International Space Station on July 11, 2011.

SpaceX gets federal clearance for South Texas launch site

http://blog.chron.com/sciguy/2014/05/spacex-gets-federal-clearance-for-south-texas-launch-site/

May 29, 2014 – SpaceX has received a green light from the Federal Aviation Administration to construct a spaceport in South Texas. The proposed 56.5-acre (23 hectares) launch site at Boca Chica beach would launch up to 12 rockets a year, including two Falcon 9 Heavy rockets, which could begin flying in 2015. These launches would be for commercial (i.e. satellites) as well as possibly NASA purposes.

Though Brownsville remains a finalist for the development of a commercial orbital launch complex, the decision will not be made until all technical and regulatory due diligence is complete. Following the release of the Final Environmental Impact Statement, the FAA will issue a final Record of Decision (ROD). Pending the ROD, there would be several other criteria that will need to be met before SpaceX decides..

The proposed site is completely undeveloped and consists of 25.43 acres of wetlands and 31.07 acres of sporadically vegetated sand dunes. The area surrounding the proposed vertical launch area is primarily used for recreational purposes.

The project was not expected to affect water resources or air quality in the area. ##
NASA & Industry Complete 1st Phase to Certify New Crew Transportation Systems

May 30, 2014 – NASA’s Commercial Crew Program and industry have completed the first step in the certification process that will enable American-made commercial spacecraft safely to ferry astronauts from U.S. soil to and from the International Space Station by 2017. The completion of the Certification Products Contracts (CPC) marks critical progress in the development of next-generation American space transportation systems that are safe, reliable and cost-effective.

"We’re making great strides toward returning human spaceflight launch capability to U.S. soil," said Phil McAlister, director of Commercial Spaceflight at NASA Headquarters in Washington. "This certification is important to ensuring our crew members have reliable transportation to and from the space station where they are conducting research essential to advancing human exploration farther into the solar system."

Under the contracts, The Boeing Company, Sierra Nevada Corporation Space Systems (SNC) and Space Exploration Technologies (SpaceX) completed reviews detailing how each plans to meet NASA’s certification requirements to transport space station crew members to and from the orbiting laboratory. NASA awarded the contracts totaling $30 million in December 2012.

"There’s more than one correct way to build a spacecraft, and CPC has been an invaluable learning process for our industry partners and the agency," said Kathy Lueders, NASA Commercial Crew Program manager. "It is extremely exciting to see the unique approach each company brings to the table."

Public-Private Partnerships Key to US Spaceflight Future, Experts Say

MAY 14, 2014 – The future of American space travel will involve significant governmental cooperation with private industry, according to a panel of spaceflight experts.

Government contracts with aerospace firms have changed the face of spaceflight in the United States. NASA will soon be using privately built spaceships to ferry astronauts to and from the International Space Station by 2017, and two companies (SpaceX and Orbital Sciences Corp.) already fly robotic vessels full of supplies to the orbiting outpost. Increasingly, commercial firms are launching satellites, supplying the International Space Station or even offer the prospect of space tourism in the near future.

Rocket Technology and other developments

SpaceX has been working for years to develop a fully and rapidly reusable rocket stage. On the other hand, the demand for launches must grow – perhaps to 50–60 flights a year to fully take advantage of this new technology.

3D printing also holds a lot of potential for future spaceflight ventures. SpaceX tested a 3D-printed metal rocket nozzle at the firm’s test stand in Texas. 3D printing can greatly lower the cost of rocket parts.

NASA Looks to Go Beyond Batteries for Space Exploration

April 9, 2014 = RELEASE 14–103

Fly wheels, such as the NASA G2 flywheel module above, are one way to store rotational energy for use by spacecraft or machines on Earth. NASA’s looking for new energy storage systems to enable our future exploration missions.
NASA is seeking proposals to develop new, more capable, energy storage technologies to replace the battery technology long in use. Core technologies solicited in this call for proposals will advance energy storage solutions for the space program and other government agencies, such as the Dept of Energy's Advanced Research Projects Agency (ARPA–E) collaborating with NASA and industry.

The goal is to create new advanced technologies that could lead to entirely new approaches for the energy needs of the NASA’s future Earth and space missions. The several high priority challenges aim at achieving safe and affordable deep-space exploration. Advanced energy storage offers new technology solutions that will address exploration and science needs and advance America's innovation economy.

**Two category areas:** "High Specific Energy System Level Concepts" will focus on cell chemistry and system level battery technologies, such as packaging and cell integration. "Very High Specific Energy Devices" will focus on energy storage technologies that can go beyond the current theoretical limits of Lithium batteries while maintaining the cycle life and safety characteristics demanded of energy storage systems used in space applications. NASA expects to make about four awards for Phase I, up to $250,000 each. ##.

---

**Ikaros: First Successful Solar Sail**


**Infographic:** [http://i.space.com/images/i/000/032/721/i02/incredible-tech-solar-lightsail–spaceship–interstellar-130913a-02.jpg](http://i.space.com/images/i/000/032/721/i02/incredible-tech-solar-lightsail–spaceship–interstellar-130913a-02.jpg)

The Japan Aerospace Exploration Agency's Ikaros solar sail is seen in deep space after its deployment on June 14, 2010, in this view taken from a small camera ejected by the sail.

Launched in May 2010, Japan’s Ikaros was the first to successfully deploy and use a solar sail at some distance from Earth, accelerating by the pressure of sunlight photons on its sail.

**Launch and unfurling**

"Ikaros" is an acronym for Interplanetary Kitecraft Accelerated by Radiation Of the Sun, a name borrowed from Greek Mythology, Icaros was the son of the master craftsman Daedalus. He and his father attempt to escape from Crete by means of wings that his father constructed from feathers and wax. Icarus' father warns him not fly too low nor too high because the sea's dampness would clog, and the sun's heat would melt his wings. Icarus ignored instructions not to fly too close to the sun, and the melting wax caused him to fall into the sea where he drowned."

Launched aboard a Japanese H–2 rocket, riding along with the main mission: a Venus orbiter called Akatsuki ("Dawn" in Japanese). The spacecraft was expected not only to go to Venus, but also to take off on its own for a 3–year trip around the other side of the sun.

The kite–shaped sail has embedded solar cells to generate electricity. It was not expected to make much power during this flight, but more to serve as a test bed for future ion propulsion–engines that not only use solar cells for electricity, but also are moved along by sails.

Ikaros successfully deployed its 14 meter (46 ft) wide sail in June 2010 through an innovative method that took advantage of spin. The package slowly unfolded as it spun at about 25 revolutions per minute, pulled out by the mass of four weighted tips working in microgravity. The folded solar sail moved out into a cross shape, at which point the spacecraft unfurled the membrane. By July, JAXA was reporting the first push of photons on the solar sail.

(Akatsuki did not successfully enter Venus' orbit, but will have another opportunity for in 2015.)

**Attitude control**
JAXA found that it could also control the orientation of Ikaros through using liquid crystal panels at the fringes of the sail. Electricity flowing through liquid crystal panels gives a reflection for the spacecraft to move forward, while turning the flow off makes the sunlight pressure more diffuse. By using the different forces of sunlight on the edges, Ikaros was able to change orientation. Testing in mid-July showed that Ikaros was able to achieve about 90 percent of the attitude control angle controllers expected before launch.

"JAXA will continue the attitude control experiment by the Ikaros to evaluate the details of the attitude control performance while continuing to conduct research on attitude control technology using sunlight pressure as a technology that enables navigation for longer in time and further in distance by a solar sail," JAXA officials wrote in August 2010.

**Pushing forward**

The original goals were met that December, but JAXA continued to use the craft to guide further development. Solar sail missions are also being studied in the United States and in European countries, Japan will lead future solar system exploration using solar power sails with continuing this kind of mission," it added, saying that solar cells could help more generally with global warming or powering future satellites.

JAXA is also planning a solar sail demonstrator "in the late 2010s" to have a 50-meter power sail and integrated ion propulsion engines. This spacecraft would head toward Jupiter and some Trojan asteroids (asteroids that stay in synch with Jupiter’s orbit, either in front of or behind the giant planet.)

---

**Are Solar Sails the Future of Space Travel?**


---

Artist's conception of Sunjammer Sail in flight above Earth. Credit: Space Services Holdings, Inc.

**Solar Sailing technology will be taking on new challenges.**

Several upcoming missions will be using gossamer "solar sails" to cruise through space much like sail boats at sea. Propellant-free propulsion could take craft cheaply and efficiently to a variety of destinations, from near-Earth space locations to the edge of the solar system and beyond.

An Interstellar Probe, proposed 15 years ago, equipped with a 400 meter (1,300 ft) wide sail could travel 2.1 billion kilometers (1.3 billion miles) per year, allowing it to escape the sun's sphere of influence in just a decade. This goal would be impossible with traditional chemical rockets.

**Paving the way**

Solar radiation pressure provides a very small push to a spacecraft. But this push is **continuous** and **can thus accelerate a probe to tremendous speeds over time.** This way is not a new idea. Jules Verne mentioned the possibility in his 1865 book "From the Earth to the Moon," and Arthur C. Clarke wrote about a solar-sailing spaceship race a century later, in the 1964 short story "Sunjammer."

Getting from concept to reality has taken a long time. The first successful demonstration came in 2010, when Japan's Ikaros probe deployed its 14 m (46-ft) wide sail and became the first craft ever to cruise through space on the backs of photons. Five months later, NASA launched the tiny NanoSail-D demonstrator to Earth orbit in November 2010, for eight months before burning up in the atmosphere.

**What's ahead**

In early 2016, when NASA plans to launch the largest—ever solar sail to space. The $27 million Sunjammer mission, which takes its name from the Arthur C. Clarke story, will use a sail built by
California-based company L’Garde that measures 38 m (124 ft) on a side. Made of an advanced material called Kaptothe, the sail is just 5 microns (about 0.0002 in) thick. It weighs less than 32 kg (70 lbs) and packs down to the size of a dishwasher, NASA officials have said.

The current plan calls for outfitting Sunjammer with some sun–monitoring instruments and sending it out to a spot about 3 million km (1.8 million miles) from Earth, along the Earth–sun line. That’s twice as far away as the Earth–sun Lagrange Point 1 (L1), a gravitationally stable spot in space that has hosted various heliophysics and space–weather missions over the years.


The purpose of the mission is to demonstrate that a solar sail is an opportune device to place solar–warning instruments closer toward the sun than is currently allowed with just conventional systems. Spacecraft positioned at L1 help researchers and the world prepare for space weather events, detecting huge clouds of super–hot solar plasma known as coronal mass ejections (CMEs) about 40 minutes before they may hit Earth (where they can disrupt power grids, GPS signals and radio communications). A probe twice as far away would provide warnings twice as early.

To the moon?

The nonprofit Planetary Society, for example, is working on a project called LightSail–1, which will launch a roughly 10–pound (4.5 kg) spacecraft to Earth orbit, to demonstrate navigational control and use sunlight pressure to increase the craft’s speed, further proving out solar–sail technology, Planetary Society representatives said.

NASA researchers are also developing a mission concept called Lunar Flashlight, which would send a tiny, sail–equipped "CubeSat" to the Moon. The sail would not just provide propulsion; it would act as a mirror for Lunar Flashlight as well, reflecting sunlight down into shaded lunar polar craters so that onboard sensors could search these features for water and other volatile compounds.

"This innovative, low–cost concept will map the lunar south pole for volatiles and demonstrate several technological firsts, including being the first CubeSat to reach the Moon, the first mission to use an 80 square meters [860 square feet] solar sail and the first mission to use a solar sail as a reflector for science observations."

Removing Space Debris objects

Sails could also help alleviate the world’s growing space–junk problem, by allowing defunct or dead satellites to de–orbit safely. The European Space Agency, in fact, hopes to conduct an in–space test of a de–orbit sail called "Gossamer" by the end of 2014.

Super Interstellar Sails

A truly enormous sail — one the size of Texas, for example — could reach another star system in a few centuries, powered by a powerful beam as the craft moved farther and farther away from the sun.

Meteoroids will pierce solar sails from time to time, slowly degrading the sails' performance.

Solar Sails could bring a new paradigm shift in spacecraft design: spacecraft and all components and systems must work for long periods, even centuries. ##

Bitcoins in Space: Private Deep–Space Venture Aims to Launch 'BitSats'

http://www.space.com/25626-bitcoins-satellites-deep-space–industries.html

April 24 – Bitcoins soon may go off the grid and into space.

"Bitcoin" is a decentralized, digital–only currency that has no central monetary authority. Instead, a peer–to–peer computer network maintains transactions and "creates" Bitcoins through a process called "mining." Users and their transactions are anonymous; there are no international exchange rates to figure out, and no middlemen to collect fees.

Bitcoins were created in 2009, after an individual known as "Satoshi Nakamoto" — a pseudonym — wrote a paper discussing the idea and how Bitcoins could work as a method of currency.


One private venture is aiming to launch a cluster of tiny satellites that would broadcast the latest bitcoin transactions from orbit.
"It's really about resilience and lowering costs," Jeff Garzik, the man behind the start-up Dunvegan Space Systems, which this week contracted the private space venture Deep Space Industries Inc. [http://www.space.com/19378-deep-space-industries-asteroid-mining-photos.html] to develop nanosatellites for the project dubbed “BitSat.” Primarily, Garzik hopes the BitSat network will empower people in off-grid locations or outside Western nations in places where an Internet connection is costly.

Deep Space Industries launched just last year with big plans to prospect near–Earth asteroids and mine them for water and metals. Deep Space chairman Rick Tumlinson, long time guru of the private space industry, said the company's move into the “cryptocurrency world” is in line with its goals.

This announcement is actually very much in line with our spacecraft development plans, including another private spacecraft system to be unveiled in a few months that will use many of the same components and systems, leading to much lower costs essential for the donation–based BitSat effort.

The deal characterized as less than US $100,000, with the payment in bitcoins. Deep Space Industries is developing the requirements for the space and ground segments of a BitSat constellation, as well as plans for the architecture, operations concept and spacecraft design.

The fundraising target between $2 million and $5 million – through a Kickstarter–like campaign – should get the first BitSats off the ground. The deal isn’t the first for bitcoins. British billionaire Sir Richard Branson recently announced that his commercial space company, Virgin Galactic, would start accepting payments in the cryptocurrency for suborbital flights aboard SpaceShipTwo.


##

SHERPA launch service deal to deploy 1200 kilo smallsat payloads

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

Spaceflight Announces SHERPA Launch Service Agreement to Deploy 1200 Kilograms of Small Satellite Payloads 999.html

MAY 5, 2014 – Spaceflight has announced it has secured a launch service agreement to orbit its "SHERPA" hosted payload and in–space transportation system. Spaceflight's inaugural SHERPA mission will deploy up to 1,200 kilograms of customer satellite payloads into low Earth orbit during the 2nd half of 2015 on an undisclosed launch vehicle. SHERPA is a free–flying platform that ferries up to 1,500 kg of rideshare spacecraft providing a hosted payload solution. SHERPA has a custom ring as its primary structure and includes a propulsion system and other spacecraft subsystems to deploy payloads in a range of orbits including low Earth, geosynchronous, low lunar and beyond.

SHERPA’s maiden mission will deliver customer spacecraft to a sun–synchronous orbit. Upon customer satellite deployment, SHERPA will test the spacecraft’s avionics, attitude determination and control system, as well as communications and other key subsystems to enable future payload delivery and hosted payload missions.

With SHERPA's first mission manifested, Spaceflight is growing its capabilities to enable cost-effective access to orbit. Starting in 2016 the company plans to offer two SHERPA rideshare missions each year, one to low Earth orbit, the other to GTO. Spaceflight has limited capacity remaining on SHERPA for the 2015 LEO mission and the 2016 GTO mission. ##

SPACE STATION NEWS

3D Printer for 'Weightlessness' Needs Special Design – VIDEO

http://www.space.com/26013-3d-printer-for-weightlessness-needs-special-design-video.html

http://www.space.com/25176-astronaut-3d-printer-space-station-video.html

To compensate for microgravity aboard the Space Station, printemaker “Made In Space” must alter mechanical configuration liquid handling. The company has taken its prototype on Zero–g flights for testing. – Editor: an interesting and fascinating video report!
Exoskeleton–Outfitted Astronaut to Control Robot Live

May 5, 2014 – http://www.esa.int/spaceinimages/Images/2014/05/Telerobotics_exoskeleton

André Schiele of ESA’s telerobotics lab, demonstrates remote robotic operations, with a 10 kg exoskeleton, an operator can control a robot – commands and feedback are sent over the regular cell–phone network. #

Also: http://www.space.com/26384-nasa-robonaut-space-tech-applications.html

Space–X Dragon Cargo Capsule makes 3rd Delivery to Space Station


April 20, 2014 – a commercial Space–X Dragon cargo ship delivered tonnes/tons of supplies to ISS, and some treats, for astronauts on board. The unmanned craft arrived at space station, floating within reach of the orbiting laboratory’s robotic arm which took care of the docking, 418 km (260 mi) above Egypt and the Nile River at the time. The procedure took just under three hours.

Hawthorne, Calif.–based SpaceX launched the Dragon cargo ship toward the space station on April 18 using its own Falcon 9 rocket, lifting off from Cape Canaveral Air Force Station in Florida. The mission is SpaceX's fourth Dragon flight to the space station and third of 12 cargo delivery missions under a $1.6 billion deal with NASA.

The craft carried 2,268 kg (5,000 lbs) of food, supplies and gear for 150 different experiments. A miniature lettuce farm, legs for robonaut–2, and a laser communications system were in the cargo.

The arrival of the Dragon was nearly a month late, first delayed to allow final checks, then further delayed due to a damaged Air Force ground radar used to support Cape Canaveral rocket launches.

Dragon’s arrival sets the stage for a spacewalk later in the week to replace a broken backup computer on the station's exterior. Called a Multiplexer–Demultiplexer or MDM, it serves as a backup for routing commands to several key systems on the station's exterior.

The backup MDM had stopped responding to commands on April 11, although the system's primary computer is still working fine. A replacement was necessary “to preserve redundancy.” ##

NASA Seeks to Evolve Space Station for New Commercial Opportunities


April 28, 2014 RELEASE 14–118 – As part of NASA's continuing effort to open low–Earth orbit to commercial space opportunities, the agency is seeking feedback on ways it can help create greater access to and use of the International Space Station for research and commercial activities.

NASA is soliciting ideas from companies interested in using the space station and the low–Earth orbit environment in innovative ways that will develop a strong commercial market and assist the agency in achieving its exploration goals. The expanding U.S. commercial space industry has been able to create self–sustaining economic opportunities in low–Earth orbit, enabled by NASA’s commitment to reducing
and removing barriers to a commercially-driven U.S. market. This has allowed the agency to sharpen its focus on deep space exploration.

NASA intends to extend U.S. commitment to the International Space Station to at least 2024 to provide opportunities, some already under implementation, to broaden private market access to the unique microgravity environment aboard the space station.

Said William Gerstenmaier, associate administrator for Human Exploration and Operations at NASA Headquarters in Washington, “after 10 years of continuous habitation in low–Earth orbit, we know microgravity provides data unattainable on Earth. We are already seeing benefits in pharmaceuticals, medical robotics and materials sciences. This RFI will help identify how to open this one-of-a-kind orbital laboratory to the private sector in better and more practical ways -- ultimately, helping to pave the way for privatelunare microgravity research facilities of the future.”

Responses to the RFI should detail ideas that could further efforts to:

- IND in low–Earth orbit
- Develop crew transportation to enable commercial activities beyond NASA requirements
- Break down access-, programmatic- and business–related barriers to realizing these objectives
- Address NASA capabilities or expertise that would help facilitate transitioning to a more commercially–driven presence, or
- Identify capabilities and resources NASA could purchase from the commercial sector to allow NASA research activities to continue beyond the life of the space station.

Responses also may provide recommendations on how private research, and other activities, could be performed on the station to foster future commercial value or demand for access to low–Earth orbit and further NASA’s exploration mission.

Responses are due by June 30. The complete RFI is available at: http://go.nasa.gov/1lot8fm

---

**NASA Sending Germs From Beloved Dinosaur Into Space (VIDEO)**

http://www.huffingtonpost.com/2014/04/15/nasa-germs-dinosaur-space-video_n_5147601.html

April 15, 2014 – NASA has sent germs into space to give scientists a better sense of how bacteria behave in microgravity -- important knowledge as the space agency gears up for long–duration manned missions into deep space. The ride was provided by a SpaceX Falcon 9 rocket.

The bacteria were collected from the surfaces of “iconic objects” across the U.S.– the Liberty Bell, the 50–yard line of San Francisco’s Candlestick Park, Al Roker’s "Today Show" weather wall, and America’s beloved "Sue the T–rex," a 67–million–year–old Tyrannosaurus rex fossil housed at the Field Museum in Chicago. Sue is considered the largest, most extensive, and best–preserved T. rex specimen ever found.

"One of our goals is to understand what microbes are living on the International Space Station and how this compares to other 'built environments' like offices, homes and cars." NASA also want to see how the lack of gravity affects microbes of all kinds. “We hope to let people know that not all microbes are bad. The majority are beneficial or harmless, and we need them!”

This study is part of Project MERCCURI, "Microbial Ecology Research Combining Citizen and University Researchers on the International Space Station. The project has encourages student scientists to participate in the collection of samples of germs from their environments.

---

**Free Time In Space? Astronaut asks For Suggestions: Video Interview**


May 6, 2014 – NASA's Human Research Program (HRP) and the National Space Biomedical Research Institute (NSBRI) will fund 26 proposals to help investigate questions about astronaut health and performance on future deep space exploration missions. The goal is to help protect astronauts as they venture farther into the solar system than ever before on longer duration missions.

The selected proposals are from 16 institutions in 8 states and will receive a total of about $17 million during a one– to three–year period. The projects were selected from 123 proposals received in
response to the research announcement "Research and Technology Development to Support Crew Health and Performance in Space Exploration Missions."

Science and technology experts from academia and government reviewed the proposals. NASA will manage 21 of the projects and NSBRI will manage five.

**Investigating the impact of the space environment on various aspects of astronaut health**

- Visual impairment
- Bone loss
- Human factors
- Neurobehavioral and psychosocial factors
- Performance
- Development and application of smart medical systems and technology.

They will also develop potential countermeasures for problems experienced during space travel. ##

**Huntington Disease to be Studied on Space Station – Video**

http://www.space.com/25574-huntington-disease-to-be-studied-on-space-station-video.html

NASA's Human Research Program (HRP) and the National Space Biomedical Research Institute (NSBRI) will fund 26 proposals to help investigate questions about astronaut health and performance on future deep space exploration missions. This research may help protect astronauts as they venture farther into the solar system than ever before to explore an asteroid and, eventually, Mars.

Proposals were selected from 16 institutions in eight states, worth about $17 million over a 1–3-year period. There had been 123 proposals. NASA will manage 21 projects and NSBRI will manage five.

**Research focus**: the impact of the space environment on astronaut health, including

- Visual impairment,
- Behavioral health
- Bone loss
- Cardiovascular alterations
- Human factors and performance
- Neurobehavioral and psychosocial factors
- Sensorimotor adaptation and the development and application of smart medical systems and technology.

HRP and NSBRI research will also develop potential countermeasures for problems experienced during space travel. The organizations' goals are to help astronauts complete their challenging missions successfully and preserve their long-term health.

HRP quantifies crew health and performance risks during spaceflight and develops strategies that mission planners and system developers can use to monitor and mitigate the risks. These studies often lead to advancements in understanding and treating illnesses in patients on Earth.

NSBRI is a NASA-funded consortium of institutions studying health risks related to long-duration spaceflight. For a complete list of the selected principal investigators, organizations and proposals, visit: http://go.nasa.gov/1mvlsLd

**MANNED SPACE VEHICLES**

**Meet Dragon V2: SpaceX's Manned Space Taxi for Astronaut Trips (Photos)**


http://www.space.com/26063-spacex-unveils-dragon-v2-manned-spaceship.html – VIDEO

http://www.space.com/26068-elon-musk-spacex-dragon-v2-glam-reveal.html

May 30, 2014 – Elon Musk, the billionaire founder of the private spaceflight company SpaceX, unveiled his firm's latest innovation — the Dragon V2 manned spaceship —Thursday night (May 29) in a stylish debut for the 21st-century space taxi for astronauts.

The Dragon Version 2 crewed spacecraft has a sleek interior design, complete with a large tablet-like computer that swivels down in front of the capsule's tan leather seats. The manned space capsule can ferry up to seven astronauts to and from the International Space Station, or anywhere else in space.

"I think it's really a big leap forward in technology. It really takes things to the next level." What it takes to bring something back from orbit, is a very difficult thing to do. Usually when something comes in
from orbital velocity, it burns up in a big fireball. But going from Dragon Version 1, we wanted to take a big step in technology."

Unlike all other manned capsules, the Dragon 2 will be able to land “like a helicopter” anywhere with pin-point accuracy. Gone are the parachute landings at sea.

And it can be quickly reused if needed.

The company has flown three of 12 cargo missions to the station for NASA under a $1.6 billion deal. The Dragon V2 is SpaceX’s entry to fly NASA astronauts to the station as part of the U.S. space agency’s commercial crew program.

Rival aerospace companies Boeing and Sierra Nevada are also developing their own commercial space taxis as part of that competition. NASA’s commercial crew program is expected to make a decision on which vehicles to advance into the next selection phase by July or August, with the goal of a manned flight by 2017. The Dragon 2 vehicle has so many innovative features that it will be hard to beat.

At the moment, the Dragon is the only robotic cargo vessel that can bring supplies back to Earth from the station. Virginia–based Orbital Sciences’ Cygnus vehicles burn up in the atmosphere.

SpaceX’s new spacecraft is designed to be reusable and it should be able to touchdown back on land with

Unlike the unmanned version of the Dragon, which uses the station’s robotic arm to berth to the orbiting outpost, Dragon 2 will be able to autonomously dock to the space station. But a pilot will also be able to park the spacecraft using manual controls if needed.

Further, Dragon 2 can be rapidly reused. "You can just reload propellants and fly again," Musk said. "This is extremely important for revolutionizing access to space because so long as we continue to throw away rockets and spacecraft, we will never have true access to space. It will always be incredibly expensive."

SpaceX engineers have updated the capsule’s heat shield and the new spaceship is outfitted with SuperDraco thrusters that can be used to move the capsule and astronauts to a safe distance if something goes wrong during launch. The SuperDraco thrusters should also aid in landings, slowing the spacecraft down as it gets closer to the ground. ##

**NASA’s 7–Person Orion Crew Capsule Passes First Integrated System Test**


[Link](http://www.nasa.gov/exploration/systems/mpcv/index.html)
Left: Engineers in the Operations and Checkout Building at NASA’s Kennedy Space Center in Florida, perform avionics testing on the Orion spacecraft being prepared for its first trip to space later this year. Center: 7-person Orion & 3-person Apollo compared Right: Capsule with cutaway section

NASA’s Orion spacecraft has proven its mettle in a test designed to determine the spacecraft’s readiness for its first flight test -- Exploration Flight Test-1 (EFT-1) -- later this year. EFT-1 will send the spacecraft more than 3,600 miles from Earth and return it safely.

An uninterrupted 24 hour test, April 8 at Kennedy Space Center in Florida verified that the crew module can route power and send commands that enable the spacecraft to manage its computer system, software and data loads, propulsion valves, temperature sensors, avionics and other instrumentation.

Since testing Orion’s computers in October 2013, NASA and Lockheed Martin engineers have installed harnessing, wiring and electronics and ran the crew module through its paces to verify all system actuators respond correctly to commands and all sensors report back as planned. More than 20 miles of wire connect the different systems being powered.

Engineers then tested the crew module for vibration testing, scheduled for the week of April 14. In May, the heat shield will be installed and the crew module attached with the service module.

During EFT-1, an uncrewed Orion spacecraft will take a four-hour trip into space, traveling 15 times farther from Earth than the International Space Station. During its reentry into Earth’s atmosphere, Orion will be traveling at 20,000 mph, faster than any current spacecraft capable of carrying humans, and endure temperatures of approximately 2,200 °C (4,000 °F).

The data form this flight will guide design decisions to improve the spacecraft that will one day carry humans to an asteroid and eventually Mars. EFT-1 is targeted for launch in December 2014.

http://www.nasa.gov/orion
http://www.space.com/19292-nasa-orion-space-capsule-explained-infographic.html

Soviet–Era Space Capsule Up for Auction in Belgium


A 2nd hand Soviet-era space capsule launched into space twice is set to be sold in Belgium on May 7th. The Russian VA (Vozvraschaemyi Apparat), return vehicle crew and cargo spacecraft is being offered by the Berlin-based Lempertz auction house at its gallery in Brussels. Estimated to sell for $1 to $2 million (US), the capsule may be the first historic spacecraft up for sale in Europe. This capsule has been in space twice and is still in “working order.”.

Two used Russian Sokol spacesuits, estimated to sell for $80,000 (US) each will also be up for sale.

Classified to commercial capsule

The VA spacecraft was first developed to fly cosmonauts around the Moon, but with the cancellation of the Soviet manned lunar program in the early 1970s, the capsule was repurposed to support plans for Russia’s classified Almaz military space stations. The 2.8 meter (9-ft), 4,100-pound (1,850 kilogram) capsule Lempertz is selling made its first trip to space atop a Russian Proton rocket on July 17, 1977. Its launch from the Baikonur Cosmodrome in Kazakhstan marked the first flight of a complete “TKS spacecraft,” comprised by a VA capsule attached to a functional cargo block (FGB).

More than two decades later, the VA capsule was sold to Excalibur Almaz (EA), a British company that planned to reuse the Soviet artifacts to offer commercial spaceflight services. In total, EA acquired
four VA capsules and two Almaz (Salyut) modules in hopes of flying the combined spacecraft as a crew and cargo transportation system to the moon, the asteroids and deep space.

The VA spacecraft being offered still bares the Excalibur Almaz name and logo, as well as the flags of Russia, the United Kingdom, the Isle of Man and the United States. ##

**NASA's Orion Spacecraft, fitted with heat shield, is Ready to Feel the Heat**


June 5, 2014 RELEASE 14-153 – Engineers completed installing the heat shield on NASA’s Orion spacecraft ahead of its first trip to space in December. The flight test will send an uncrewed Orion 3,600 miles into space before returning it to Earth for the splashdown in the Pacific Ocean. The heat shield will help protect the Orion crew vehicle from temperatures of about 4,000 degrees Fahrenheit during its reentry into Earth’s atmosphere. Image Credit: NASA/Daniel Casper

**Latest News June 28th:** http://www.space.com/26383-nasa-flying-saucer-test-ldsd.html

**China's 'Lunar Palace' for Space Research Tested on Earth**


Layout of China's Lunar Palace 1, an Integrative Experimental Facility for Permanent Astrobase Life–Support Artificial Closed Ecosystem (PALACE) Research.

Three volunteers stepped out of China's Lunar Palace 1 last month after a 105-day shakeout mission — not on the Moon, but on Earth. The three Chinese biospherians carried out the first long-duration multicrew sealed-cabin research at the Beijing University of Aeronautics and Astronautics.

The facility is a 500–cubic-meter (17,657 cu. ft) capsule that covers an area of 160 square meters (1,722 sq ft) and consists of one integrated module (living room, work room, bathroom, a waste-disposal room) and two plant cultivation modules.

The volunteers are two women and one man all from the University building this facility.

The Lunar Palace 1 project started in March 2013 with system construction, followed by the commissioning of the facility, leading up to the 105-day mission that ended May 20.

Ecological life support – “the world's most advanced closed-loop life-support technology so far”
Corn and peanuts, were grown during the test, as were lentils and cucumber vine plants. Human waste was handled by a biofermentation process. Food residue and other byproducts were treated by biotechniques and were used for plant cultivation. The core of Lunar Palace 1 includes a Bioregenerative Life Support System that is essential for astronauts to live and work in space for long-duration missions, thus making it possible for lengthy spaceflights and planetary exploration.

This is the first bioregenerative life-support base developed in China, and the third overall in the world. China’s bioregenerative life-support research will play a significant role in its future missions: a manned Moon landing, and lunar base establishment, even Mars exploration.

**Long journeys ahead**

Only with an efficient, fully closed biologically regenerative life-support system can we seriously move forward with an anticipated human Mars exploration. “We still have a long way to go before space crews can live entirely on food raised in their onboard gardens, but this long journey has, as Confucius might have said, started with the first step.”

---

### MISSION TO PLANET EARTH

**Satellite Images May Predict Volcanic Eruptions**


The science of volcanology has come a long way since Mt. Vesuvius destroyed the Roman city of Pompeii in 79 A.D. New Satellite-based systems offer a way of measuring whether a volcano is likely to erupt soon. Satellite radar maps show that volcanoes usually deform before an eruption, due to magma on the move below. Measuring that deformation from space could make it possible to forecast when volcanoes will erupt, especially in remote areas that can’t be accessed easily by scientists on the ground.

Using statistics, the team found that 46 percent of deforming volcanoes erupted, whereas only 6 percent of volcanoes erupted without deforming, suggesting that deformation can be a good indicator of eruptions. Satellite radar can be used to identify volcanoes bulging with magma, which can then be investigated from the ground.


But there are factors that can lead to deformation that don’t always result in an eruption. A lot depends upon type of volcanic rock, its tectonic characteristics, the depth of the magma and the rate at which it flows all play roles.

The satellite record is good for capturing volcanoes that erupt every few months or years, but not for volcanoes with longer eruption cycles. Satellites typically capture radar images of volcanoes only a few times per year, so they may miss the shortest eruption cycles. The European Space Agency plans to launch Sentinel–1 to collect images all over the globe every six to 12 days.

##
India Launches Its 2nd Navigation Satellite


India launched its second navigation spacecraft aboard a Polar Satellite Launch Vehicle, to continue building an independent space-based system to provide positioning services over Indian territory.

![Image of navigation satellite](http://geoawesomeness.com/wp-content/uploads/2013/07/Inside_IRNSS_1499475a.jpg)

The rocket placed the spacecraft in an orbit with a high point of 20,611 km (12,807 mi), a low point of 286 km (176 mi) and an inclination of 19.2 degrees, close to prelaunch predictions.

Using the PSLV XL workhorse version, the most powerful configuration featuring enlarged boosters, this was the 26th PSLV mission since 1993 and the launcher’s 22nd successful flight in a row.

The spacecraft is the second member of the Indian Regional Navigation Satellite System, a seven-satellite network flying in high-altitude orbits thousands of miles over the Indian Ocean. Weighing 1,432 kg (3,157 lbs) with a full load of propellant, the IRNSS 1B satellite maneuvered into a 35,400 km (22,300-mi)–high geosynchronous orbit at 55 degrees east longitude with an inclination of 29 degrees to the equator. It will drift north and south of the equator, tracing a “figure–eight” pattern over the Indian Ocean, Arabian Sea and South Asia.

**Indian Regional Navigation Satellite System Infographic:**


Designed for a 10–year lifetime, IRNSS 1B joins the first one launched in July 2013. Five more Indian are scheduled for launch by mid–2015.

The program’s positioning services will reach users in India and surrounding regions within about 1450 km (900 mi) from the Indian mainland. IRNSS services will be freely available to the public, but some capabilities will be restricted to government users.

IRNSS 1B carries L–band and S–band navigation payloads and a rubidium atomic clock to keep time. A C–band transponder and laser reflectors will help engineers determine the distance to the satellite in orbit, a requirement for precise navigation services. The system will also aid marine traffic, emergency response officials, vehicle tracking applications, mobile communications, and mapping.

Four IRNSS satellites will operate in inclined geosynchronous orbits like IRNSS 1A and 1B, while three spacecraft will launch into geostationary orbit over the equator. ##

---

Vietnam’s First Optical Satellite Reports Success


April 8, 2014 – A year ago, in 2013, Vietnam launched its first optical satellite into space. Now, Vietnam reports the satellite’s success.

**VNREDSat-1** (Vietnam’s first **Natural Resources, Environment and Disaster monitoring satellite**), was launched into orbit from the Guiana Space Center in Kourou, French Guiana on May 7 The satellite has been monitoring and studying the effects of climate change to help the country predict and take measures to prevent natural disasters, as well as to optimize the management of its natural resources.

The project was coordinated by the Vietnam Academy of Science and Technology (VAST) and Ministry of Natural Resources and Environment to create a complete supervision system independent of ground receiving stations and remote sensing imaging centers.
By the end of 2013 VNREDSat-1 had taken 20,463 photos of the world, 5,043 were of Vietnam.

Costa Rica’s first satellite to be launched into space in 2016


April 22, 2014 – The Central American Aeronautics and Space Administration (ACAE) on Monday officially announced that the first Central American satellite, built in Costa Rica, will be launched into space in 2016. The satellite will collect and relay daily data on carbon dioxide to evaluate the effects of climate change. That data will be sent to monitoring bases in tropical forests at the Santa Rosa National Park in Costa Rica’s northwestern province of Guanacaste.

Information will then be broadcast to another base station at labs operated by the Technological Institute of Costa Rica (ITCR) for analysis and processing.

The device weighs less than 10 kilograms and technically is considered a miniature satellite, or picosatellite [cubesat]. The launch likely will take place outside of Costa Rica, which currently has no launch infrastructure. ACAE has already been talking to South Korea and NASA about launch options.

Private Team wants to Bring 36yr old Earth–Sun Probe out of Retirement

http://www.space.com/25730-nasa-isee3-spacecraft-revive-crowdfunding.html

May 1, 2014 – The retirement of a 1970s-era NASA spacecraft is about to end. A crowdfunded team of engineers, programmers and “citizen scientists” plans to bring the International Sun–Earth Explorer 3 probe (ISEE-3) out of retirement. Launched in 1978, it ceased science operations in 1997, 18 years later. The group intends to move ISEE-3 from its orbit around the Sun to a stable spot close to Earth where it would be given a new job, studying space weather. But another assignment being considered would have it or it chase down a comet, just as it did several times during its working life.

The “ISEE-3 Reboot Project” could return useful data and help excite the public about space science. And it may inspire similar spacecraft-salvaging efforts, starting a trend to put “salvageable but retired” satellites back to work – a lot less expensive than building and launching replacements.. With so many “retired” satellites still in orbit, it’s inevitable that somebody is going to say, “OK, you’re done with it; can I use it?” An important goal of the project is to get people to think differently.
A long and varied career

ISEE-3 was a joint NASA/European Space Agency project, with a 1978 launch. It had 13 different science instruments to study cosmic rays and the solar wind, the stream of charged particles flowing from the sun. At first it was stationed at the Earth–sun Lagrange Point 1 (ES–1), a gravitationally stable spot about 1.5 million km (930,000 mi) from Earth.

But in the early 1980s, the probe was given a new mission and a new orbit around the sun, along with a new name — The International Cometary Explorer, or ICE. In 1985, ICE chased down Comet Giacobini–Zinner, becoming the first probe ever to fly through the tail of a comet. Its next assignment was to fly by famous Halley's Comet in March 1986.

In 1991, this versatile probe was given yet another new mission, studying the Sun, and its large explosions of superheated plasma known as coronal mass ejections. Finally, in 1997, NASA “retired the craft but neglected to “turn it off.” So it has been in mission limbo for 14 years!

As it happens, ISEE-3 still has a fair amount of fuel left, and at least some parts of it still function, silently begging for a new mission, a productive yet inexpensive afterlife..

The new owners do not know if all the instruments will still work. Yet both transmitters work just as they should, a good indication that a lot of it works. That it still sends out signals suggests that a lot of the instruments might still be operable.

Putting ISEE-3 back to work

Cowing, fellow project co-leader Dennis Wingo [author of "Moon Rush"] and their colleagues are willing to bet that they can establish contact with ISEE-3, order it to fire its engines and bring it close to Earth. They expect it won't be that simple. The equipment that NASA used to command the probe no longer exists. So the reboot team has been combing through the ISEE-3 mission files, gathering information needed to create a virtual version of this communications hardware. “The effort is akin to building a website that allows users to run older versions of computer operating systems.”

The team is getting some help of both active and retired NASA personnel, though agency itself is not yet officially involved. There is no funding available to support the effort — nor is this an agency priority. So the rehab team is turning to crowdfunding to raise the needed funds. A crowdfunded effort such as this can have education and public outreach value.

UPDATE: Team Reaches Crowdfunding Goal on May 14th, 4 days before the deadline

http://www.space.com/25918-crowdfunding-goal-reboot-isee3-spacecraft.htm

The money will help develop the virtual communications gear, contact and control ISEE-3 using a large radio dish at Morehead State University in Kentucky.

Clock is ticking ISEE-3 is cruising past Earth soon and won't be back again for 30 to 40 years. The team needs to contact it by the end of May at the latest, command the probe to perform some engine burns by mid-June. The team hopes that trajectory-altering maneuvers will send ISEE-3 back to ES–1, after a close flyby of the Moon on Aug. 10 that will bring the probe within 50 km (30 mi) or so of the lunar surface.

Then the team must decide what to do with the probe: leave it at ES–1 to study space weather, or have it fly by another comet, should an ideal opportunity arise.

The reboot team want its science observations to be accessible to the public in an open-source fashion. To learn more about the ISEE-3 revival crowdfunding project, visit:

www.rockethub.com/projects/42228-isee-3-reboot-project-by-space-college-skycorp-and-spaceref

The effects of climate change on Earth can be seen clearly in photos taken by satellites in space. These images are vital tools in protecting our home planet, NASA chief Charles Bolden wrote May 6. Bolden's comments followed the release of the Third U.S. National Climate Assessment report today by the White House. According to the report, the fallout from human-induced climate change will result in more extreme weather events, longer and hotter summers and other extreme regional effects.

Some of those effects, like more frequent wildfires and coastal flooding, are visible from space through the lens of our satellites. "The U.S. National Climate Assessment combined observations from NASA's incredible fleet of Earth observation satellites with surface-based and satellite data from our interagency and international partners, to help us understand what's going on globally in areas such as polar ice, precipitation extremes, temperature change, sea level rise and forest ecosystems.

NASA missions are vital to the National Climate Assessment report, and the space agency has big plans to continue that role this year with five NASA Earth Science missions to be launched into space in 2014 alone. Together with NASA's existing fleet of satellites, airborne missions, researchers, and the unique platform of the International Space Station (ISS), these new missions will help answer some of the critical challenges facing our planet today and in the future."

In February, NASA and Japan launched the Global Precipitation Measurement core observatory to track global rainfall patterns. The next satellite to launch will be the Orbiting Carbon Observatory, which is slated to blast off in July to map the carbon dioxide in Earth's atmosphere. It is a replacement for the first OCO satellite, which was lost during a failed launch in 2009.

Two of the new climate-monitoring NASA instruments will be delivered to the International Space Station. The RapidScat instrument will monitor ocean wind speeds and direction, while the Cloud-Aerosol Transport System will use light-detection and ranging (or lidar) to track dust, smoke and other particles in Earth's atmosphere.

Finally, NASA will launch the Soil Moisture Active Passive mission in November to study soil moisture around the world, as well as monitor the timing of freeze thaws.

"All of the data NASA collects is widely disseminated and helps many people to make wise decisions about how we care for our planet, as well as predict and cope with changes in climate and extreme weather events," Bolden wrote. "The National Climate Assessment is an example of how critical the NASA data and research are."

Google has considered both balloons and drones in its quest to spread high-speed Internet access across the globe. Now it plans to invest billions in a fleet of satellites that could help reach "the other 3 billion" people who live in regions of the world lacking broadband Internet access.

Google wants to launch a larger fleet of smaller satellites into an even lower Earth orbit. These would weigh less than 113 kilograms, as opposed to the 680 kilograms of O3b's current design.

How does it work?
The new satellite initiative represents the latest evolution in Google's race against Facebook to reach potential new customers in regions of the world without broadband Internet access. Google initially seemed to put high hopes on Project Loon's effort to use thousands of balloons to help provide the necessary geographical coverage. But the company's recent acquisition of Titan Aerospace, a startup developing solar-powered drones capable of serving as "atmospheric satellites," may provide a new direction in combination with O3b’s satellites.

Google now has ownership or a stake in most of the five technological approaches IEEE Spectrum previously singled out as being capable of spreading broadband access worldwide. One of the technologies is metamaterial antennas made by Kymeta Corp that can track moving satellites more cheaply. More: [http://www.gizmodo.com.au/2014/01/how-swarms-of-tiny-satellites-are-creating-a-real-time-google-earth/](http://www.gizmodo.com.au/2014/01/how-swarms-of-tiny-satellites-are-creating-a-real-time-google-earth/)

### NASA to Launch Carbon Dioxide-Monitoring Spacecraft in July

June 12, 2014 NASA RELEASE 14–166 – NASA’s first spacecraft dedicated to measuring carbon dioxide levels in Earth’s atmosphere is set for a July 1 launch from Vandenberg Air Force Base, California.

The **Orbiting Carbon Observatory-2** (OCO-2) mission will provide a more complete, global picture of the human and natural sources of carbon dioxide, as well as their “sinks,” the natural ocean and land processes by which carbon dioxide is pulled out of Earth’s atmosphere and stored.

Carbon dioxide, a critical component of Earth’s carbon cycle, is the leading human-produced greenhouse gas driving changes in Earth’s climate. “Carbon dioxide in the atmosphere plays a critical role in our planet’s energy balance and is a key factor in understanding how our climate is changing,” said Michael Freilich, director of NASA’s Earth Science Division in Washington.

“With the OCO-2 mission, NASA will be contributing an important new source of global observations to the scientific challenge of better understanding our Earth and its future.”

---

**Artist's rendering of NASA's Orbiting Carbon Observatory (OCO)-2**

VIDEO: [https://www.youtube.com/watch?v=-uP_fqEyWg#t=112](https://www.youtube.com/watch?v=-uP_fqEyWg#t=112)
Clean Up Space Junk or Risk Real-Life 'Gravity' Disaster, US Lawmakers Say

The United States must bolster efforts to address the alarming amount of space junk surrounding Earth, or risk potentially catastrophic collisions in orbit. Such real-life accidents could resemble the horrifying destruction depicted in the recent science-fiction thriller movie, “Gravity.”

Unfortunately, “orbital debris,” or space junk, is not science fiction, but a growing problem. Dealing with the increase in orbital debris will not be easy because of the great variety of sizes and orbits affected.

In the US Department of Defense, the Joint Functional Component Command for Space (JFCC-Space) currently tracks 23,000 objects in low-Earth orbit. NASA officials have estimated that roughly 500,000 pieces of space junk larger than a marble circle the planet, and there could be more than 100 million tiny fragments, some as small as flecks of paint, that race around Earth at speeds of 28,000 km/h (17,500 mph).

Not only have NASA space shuttles and the International Space Station had to dodge space junk over time, but two major events have added considerably to the debris problem in orbit. In 2007, China intentionally destroyed a defunct satellite as part of an anti-satellite test that created a vast clouds of debris. The 2009 collision between two unmanned spacecraft, a U.S. communications satellite and a dead Russian satellite, created even more debris.

Witnesses suggested ways Congress might approach policies related to space traffic management. Currently, the Department of Defense oversees surveillance of space as part of its national defense duties, yet with civil agencies, private companies and commercial space travelers all potentially sharing the space environment in the near future, it may be time to re-examine the policing of this increasingly congested orbital region.

The FAA is the sole federal agency with the authority to grant licenses to commercial space operators. Part of this regulatory process includes working with private companies to ensure their rocket launches will not generate even more debris in orbit. But, the FAA does not have the authority to regulate commercial activities in space. That job falls to the FCC for communications satellites, and to the National Oceanic and Atmospheric Administration (NOAA) for commercial Earth-watching spacecraft.

To avoid any Hollywood-type disasters in space, the government must act soon. ##

Resources:
http://en.wikipedia.org/wiki/Space_debris
http://orbitaldebris.jsc.nasa.gov
http://www.esa.int/Our_Activities/Operations/Space_Debris
http://www.iadc-online.org
http://www.congrexprojects.com/2013–events/13a09/introduction
China’s lunar rover “Yutu” still alive, but weak

http://www.spacedaily.com/reports/Chinese_lunar_rover_alive_but_weak_999.html

May 29, 2014 – China’s lunar rover Yutu is still alive and functional after more than five months on the Moon, but its functionality has been weakened considerably by the bitterly cold lunar nights after the rover experienced a “mechanical control abnormality” in January. The rover can still send data back to Earth via the Chang’e-3 lander which carried Yutu to the moon. But its wheels are no longer functioning nor are the solar panel designed for thermal insulation during lunar nights.

With each lunar night, the functionality of Yutu is further weakened.

Russia to launch 3 Moon Rovers from 2016 to 2019


March 09, 2014 (missed in previous issue of TTSIQ)

Roscosmos, will send three automated rovers to the Moon from 2016 to 2019 as part of its plan to eventually send a manned mission to Mars.

“Stage one priority is research projects to be carried out by automated rovers on the Moon and Mars – Luna-25, Luna-26, and Luna-27. The first one will be launched in 2016, the second one in 2018, and the third one in 2019.

• Luna-25 will land around the Moon’s South Pole for a demonstration mission.
• Luna-26 will travel along the Moon’s orbit to conduct remote probing and data relaying.
• A third vehicle will carry a drilling unit to search for water ice in sub-polar regions.

Following this initial stage of the lunar plan, Roscosmos will move to the next phase, which will involve the delivery of Moon soil to Earth by Luna-28 and Luna-29.

Eventually, Roscosmos hopes to establish permanent lunar research bases. Relevant technologies are now being developed. Researchers are working on options of long-term autonomous stay of humans on the Moon. As an option, Roscosmos is considering placing a powerful observatory on the Moon.##

Preliminary results from the LADEE mission around the Moon


Continual bombardment

From LADEE's low-orbit swings around the moon, its instruments have scoped out the Moon’s dusty exosphere. LADEE's Lunar Dust Experiment (LDEX) instrument has identified the dust cloud surrounding the Moon, maintained by micrometeoroid bombardment of the lunar surface. The Moon does have an atmosphere made out of dust particles. LDEX is expected to characterize in detail the ejecta cloud surrounding the Moon, including the size, velocity and angular distribution of the ejecta particles.

Discovering this cloud opens up a whole new avenue for planetary science. The transmitted data set from LDEX has identified "a whole forest of bursts." LDEX has produced large amounts of data about the Moon’s dust exosphere and deepened insight into the physics of the phenomenon.

Preliminary data gleaned by LADEE also includes a look at China’s Chang’e 3 moon lander's activities — specifically, the Chang'e 3’s exhaust plume and its impact on the moon’s exosphere and landscape as the craft powered its way down to Mare Imbrium (Sea of Rains) on Dec. 14 of last year. That work is still in the early stages of analysis. It is estimated more than 446 kg (980 lbs) of water was...
released during Chang'e 3’s entire descent burn that took some 12 minutes. Nearly 122 kg (270 lbs) of that water actually intersected with the Moon’s surface.

**Implications for future Moon exploration**

If you’re setting up a permanent presence there, with rockets coming and going, you need to know how exhaust from landings and takeoffs might come into contact with moon-situated instruments and equipment (telescope mirrors, for example). When a spacecraft lands on the Moon, it produces a global but short-term perturbation to the lunar exosphere. And because comets and meteoroids also bring water and other volatiles to the Moon, "studying the propagation of the exhaust products by modeling the LADEE observations can inform us on how those volatiles may eventually migrate to the cold traps in permanently shadowed regions on the Moon." In short LADEE has been a very productive mission. ##

---

### 'Graveyard' on the Moon's Far Side Welcomes NASA’s LADEE


The far side of the Moon got a special new crater when NASA’s LADEE spacecraft made a high-speed crash into the lunar surface.

LADEE (short for Lunar Atmosphere and Dust Environment Explorer) had been studying the Moon’s thin atmosphere — called an “exosphere” — and the lunar dust environment since it began orbiting the Moon last October.

"If you hit anything at 1,600 m (5,250 ft) per second, it’s by no means gentle, This was a very, very high-speed impact, and even though there's a possibility of tumbling across the surface, there's nothing gentle about it. LADEE was destroyed in the process.


The intentional crash of a NASA LADEE probe on the far side of the Moon added one more body to an already substantial graveyard of space hardware. LADEE slammed into the Moon's surface, as planned, in the early hours of April 18, bringing an end to a $280 million mission launched in September 2013.

LADEE’s smash landing on the far side is far from unique, The total is six so far, and no “landers.” … To date no human–built object ohas ever landed on the far side Those six are. all American, except for Okina, one of the little sub–satellites of the Japanese Kaguya mission that orbited the Moon from September 2007 to June 2009. The others include Ranger 4 back in the mid–60s, then, three of the five Lunar Orbiters, and a sub–satellite released in lunar orbit by Apollo 16.

There could be others, as no one yet knows the crash sites of some hardware — such as the Apollo 10 Lunar Module (LM) descent stage; the Apollo 11 and 16 LM ascent stages; the Apollo 15 sub–satellite; and the former Soviet Union’s Luna 11, 12, 14, 19 and 22 missions. In addition, there’s India’s Chandrayaan 1 (a near south polar site was intended) and another sub–satellite ejected during Japan's Kaguya mission.

LADEE's final resting place is unclear at the moment, but NASA plans to look for the spot with its sharp–eyed Lunar Reconnaissance Orbiter probe (LRO). But some researchers think LADEE may have crashed into a crater called Sundman V. If LADEE’s final resting spot is indeed in that area, there is some good news: Pre–impact imagery of Sundman V is available, and contrasting old and new LRO camera photos should enable a focus on the crash site.

LRO won’t be able to train its sharpshooting camera on the area for several weeks. Moreover, it is not clear if LADEE might have struck Sundman V on the east side or west side of the crater. Space archaeologists are eager to find out where LADEE went down. ##

---

### How the Moon Formed: Lunar Rocks Support Giant Impact Theory


A new analysis of lunar rocks now supports the idea that the Moon was born in a gigantic collision between the nascent Earth and another smaller planet–size body, scientists say. We think the Moon came into being shortly afterward the Earth formed about 4.5 billion years ago. The prevailing explanation for the Moon’s origin, known as the Giant Impact Hypothesis, is that it resulted from two protoplanets (or embryonic worlds) that slammed together — the early Earth, and a Mars–size object called Theia. A lot of the debris from this collision went on to form the Moon.

This hypothesis is very good in explaining most of the Moon's features. For instance, why the Moon is low in substances that evaporate fairly easily, such as water — these volatile materials escaped in the heat of the impact's aftermath.

Compared to Earth, the Moon is still bone dry. However, scientists still have doubts about this idea due to the chemistry of the Moon. Models of the giant impact often say the Moon should be about 70 percent Theia material. The problem is, most planets in the solar system have unique chemical makeups, and the Earth and its Moon should, too. However, they appear similar when it comes to isotopes — more so than might be suggested by most Theia models.

Now, for the first time, scientists have found differences in the isotopic makeup of Earth and the Moon — findings that support the Giant Impact Hypothesis for how the Moon formed. Researchers focused on ratios between two different isotopes of oxygen — oxygen–16, which has eight neutrons in its nucleus, and oxygen–17, which has nine. Oxygen isotope ratios can vary greatly from planet to planet. They looked at lunar rocks provided by NASA that were collected by astronauts during the Apollo 11, 12 and 16 missions. The researchers discovered that these rocks contained slightly more oxygen–17 than oxygen–16 — but a statistically significant amount more — when compared to Earth rocks.

Such a collision might help explain why the Moon is low in substances that evaporate fairly easily, such as water — these volatile materials escaped in the heat of the impact's aftermath.

The reports of tiny amounts of water on the Moon that now come up here and there do not change that view. Compared to Earth, the Moon is still bone dry. However, scientists still have doubts about this idea due to the chemistry of the Moon. Models of the giant impact often say the Moon should be about 70 percent Theia. The problem is, most planets in the solar system have unique chemical makeups, and the Earth and its Moon should, too. However, the Earth and the Moon appear similar when it comes to isotopes — more so than might be suggested by most Theia models.

Now, for the first time, scientists have found differences in the isotopic makeup of Earth and the Moon — findings that support the Giant Impact Hypothesis for how the Moon formed.

Chemistry of the Moon

Researchers focused on ratios between two different isotopes of oxygen — oxygen–16, which has eight neutrons in its nucleus, and oxygen–17, which has nine. Oxygen isotope ratios can vary greatly from planet to planet. Initially, scientists had looked at lunar rocks that were blasted off the Moon by cosmic impacts and landed on Earth as meteorites. However, these samples were contaminated by the oxygen isotopes in water from Earth.

But looking at lunar rocks provided by NASA that were collected by astronauts during the Apollo 11, 12 and 16 missions, researchers discovered that these rocks contained slightly more oxygen–17 than oxygen–16 — but a statistically significant amount more — when compared to Earth rocks.

The new data suggest that the Moon may be made up of about 40 percent Theia. The investigators proposed that Theia was similar to meteorites known as enstatite chondrites.

Future research can look for differences between the Moon and Earth when it comes to other isotopes, such as those of titanium. Scientists could also investigate another possible explanation for these new findings — for instance, that a veneer of material low in oxygen–17, such as meteorites known as carbonaceous chondrites, accreted onto Earth after the Moon formed. ##

### Misleading mineral may have resulted in overestimate of water in Moon

[www.space-travel.com/reports/Misleading_mineral_may_have_resulted_in_overestimate_of_water_in_moon_999.html](http://www.space-travel.com/reports/Misleading_mineral_may_have_resulted_in_overestimate_of_water_in_moon_999.html)

April 2, 2014 - The amount of water present in the Moon may have been overestimated in a study of the mineral apatite, says a research team of the UCLA Department of Earth, Planetary and Space Sciences.
The image is a map of calcium within a polished thin slice of a lunar rock. The high calcium content in apatite is indicated by the bright pinks and reds, while surrounding minerals with lower calcium content are shown in blues and black. Core to rim zoning of water in crystals such as this one demonstrates the presence of the apatite fractionation, responsible for the high water content of lunar apatites on an otherwise dry Moon.

The team created a computer model to accurately predict how apatite would have crystallized from cooling bodies of lunar magma early in the Moon’s history. Their simulations revealed that the unusually hydrogen–rich apatite crystals observed in many lunar rock samples may not have formed within a water–rich environment, as was originally expected. It has been a long–held assumption that the hydrogen in apatite is a good indicator of overall lunar water content.

The new results show that there is not as much water in lunar magma as apatite would have us believe. For decades, scientists believed the Moon was almost entirely devoid of water. However, the discovery of hydrogen–rich apatite within lunar rocks in 2010 seemed to hint at a more watery past. Scientists originally assumed that information obtained from a small sample of apatite could predict the original water content of a large body of magma, or even the entire Moon, but the new study indicates that apatite may, in fact, be deceptive.

“The high water content within lunar apatite results from a quirk in the crystallization process rather than a water–rich lunar environment.”

When water is present as molten rock cools, apatite can form by incorporating hydrogen atoms into its crystal structure. However, hydrogen will be included in the newly crystallizing mineral only if apatite’s preferred building blocks, fluorine and chlorine, have been mostly exhausted.

“Early–forming apatite is so fluorine–rich that it vacuums all the fluorine out of the magma, followed by chlorine. Apatite that forms later doesn’t see any fluorine or chlorine and becomes hydrogen–rich because it has no choice.” Therefore, when fluorine and chlorine become depleted, a cooling body of magma will shift from forming hydrogen–poor apatite to forming hydrogen–rich apatite, with the latter not accurately reflecting the original water content in the magma.

This has implications for how the Moon originally formed, when hydrogen and other volatile elements should not be present at all in lunar rocks. Assuming that the Moon formed when a giant impact tore free a large chunk of Earth more than 4 billion years ago, the Moon would have been completely molten, and lighter elements such as hydrogen should have bubbled to the surface and escaped into space. Since hydrogen is a key component of water, a moon formed by a giant impact should be dry.

The majority of lunar samples are in fact very dry and missing lighter elements. Yet hydrogen–rich apatite crystals are found in a whole host of lunar samples and have presented a paradox for scientists. Somehow, despite the Moon’s fiery beginning, some water and other volatiles may have remained, though perhaps not as much as apatite initially implied.

“We had 40 years of believing in a dry Moon, and now we have some evidence that the old dry model of the moon wasn’t perfect,” Boyce said. “However, we need to be cautious and look carefully at each piece of evidence before we decide that rocks on the moon are as wet as those on Earth.”

The researchers plan to determine how badly apatite has distorted our view of the Moon and how we can best see past it to get at the Moon’s origin.

Water in Moon rocks provides clues and questions about lunar history

Water in Moon rocks provides clues and questions about lunar history

A recent review of hundreds of chemical analyses of Moon rocks indicates that the amount of water in the Moon’s interior varies regionally – and this provides clues about how water originated and was redistributed in the Moon as well as providing a new tool to unravel the processes involved in the formation of the Moon, how the lunar crust cooled, and its impact history.

We are not talking about liquid water, but water trapped in volcanic glasses or chemically bound in mineral grains inside lunar rocks.

- Rocks originating from some areas in the lunar interior contain much more water than rocks from other places.
- The hydrogen isotopic composition of lunar water also varies from region to region, much more dramatically than in Earth.
The present consensus is that the Moon formed as the result of a giant impact of an approximately “Mars-sized” protoplanet with the proto-Earth. The water in the Moon is a tracer of the processes that operated in the hot, partly silicate gas, partly magma disk surrounding Earth after that impact. The source of the Moon's water has important implications for determining the source of Earth's water, which is vital to life. There are two options:

- Either, water was inherited by the Moon from the Earth during the Moon-forming impact,
- Or it was added to the Moon later by comets or asteroids. It might also be a combination of these two processes.

"Basically, whatever happened to the Moon also happened to the Earth." Researchers compiled water measurements from lunar samples performed by colleagues from around the world, as well as their own. Investigators measured hydrogen and its isotope, deuterium with ion microprobes, which use a focused beam of ions to sputter ions from a small rock sample into a mass spectrometer.

The ratio of hydrogen to deuterium can indicate the source of the water or trace magmatic processes in the lunar interior.

When water was first discovered in lunar samples in 2008, it was very surprising because from the time Apollo astronauts brought lunar samples, scientists thought that the Moon contained virtually no water, a fact consistent with the idea that blossomed during the Origin of the Moon conference in Kona in 1984 -- that the Moon formed by a giant impact with the still-growing Earth, leading to extensive loss of volatile chemicals. But new work shows that lunar formation and accretion were more complex than previously thought.

Stay tuned as this new research is far from finished. ##

**Why the Moon's 'Dark Side' Has No Face**


June 12, 2014 – Heat radiating from the young Earth could help solve the more than 50-year-old mystery of why the far side of the Moon, facing away from Earth, lacks the dark, vast expanses of volcanic rock that define the face of the Man in the Moon as seen from Earth. The “Man in the Moon” feature was born when cosmic impacts struck the side that faces Earth. These collisions punched holes in the moon's crust, which later filled with vast lakes of lava that formed the dark areas known as maria or "seas."

In 1959, when the Soviet spacecraft Luna 3 transmitted the first image of the never before seen “farside” that faces away from Earth, what struck everyone was the near total absence of maria (except for the one, the Soviets invoked “discoverer’s privilege to christen Mare Moscoviensis), “Why” has been called “the Lunar Farside Highlands Problem.”

Scientists soon realized that the Farside Crust was much thicker than the Nearside Crust (see illustration added by the editor, at far right, above.) Why was this so? The most recent suggestion has been that when an early “Mars sized” planet, now dubbed Thea, smacked into Earth, the debris blasted into space at first formed two “moons” – one much smaller than the other (“Luna” and “Lunetta”?) and that eventually Lunetta impacted the Moon on the farside, adding thickness to the crust there.

Now scientists have another idea. The moon and Earth are generally thought to have orbited very close together after they formed, 10 to 20 times closer to each other than they are now. The gravitational tidal forces the moon and Earth exerted on each other braked their rotations, resulting in the Moon always showing the same face to Earth, a situation known as tidal lock. Heat from the young still molten Earth slowed the formation through cooling of the nearside crust, caused the difference in crustal thickness.
The lunar crust possesses high concentrations of aluminum and calcium, elements that are very hard to vaporize. As rock vapor starts to cook, the very first elements that “snow out” are aluminum and calcium.

These elements would have more easily condensed in the atmosphere on the colder far side of the Moon. Eventually, these elements combined with silicates in the mantle of the Moon to form minerals known as plagioclase feldspars, making the crust of the far side about twice as thick as that of the near side. In short, "Earth.

What has that to do with the “Man in the Moon” nearside appearance? When collisions from asteroids or comets blasted the Moon’s surface, they could punch through the nearside’s crust to generate maria. In contrast, impacts on the farside's thicker crust failed to penetrate deeply enough to cause lava to well up, instead leaving the far side of the moon with a surface of valleys, craters and highlands, but almost no maria.

If the farside crust had been as thin as that on the nearside, the vast farside southern hemisphere “South Pole – Aitken Basin,” the deepest on the Moon, would have been a vast mare, rivaling the nearside’s Oceanus Procellarum.

Future research could generate detailed 3D models testing this idea. The authors detailed their findings June 9 in the Astrophysical Journal Letters. ##

**GRAIL Finding: Earth's gravitational pull stretches the Moon’s surface**

May 30, 2014 – Anyone who's been to the beach -- and seen the ocean's tides -- knows the Moon's gravitational effects on Earth are rather obvious. But the coordinated effects of Earth's gravitational pull on the Moon are less apparent.

A new study by NASA scientists shows even the shape of the Moon's all-solid surface changes in response to the position of Earth. This deformation is very challenging to measure, but is enough to give us clues about the Moon’s interior.

The Moon looks perfectly round in the sky not only because the deformation is so slight but because it is in the line of sight, front to back. These subtle changes in the Moon's surface appeared in extremely precise measurements by NASA's Lunar Reconnaissance Orbiter (LRO), and NASA's Gravity Recovery and Interior Laboratory (GRAIL) mission.

Just as the Moon pulls on Earth’s oceans, the surface of the Moon bulges slightly, rising some 6 meters (20 ft) in places. And as the newly collected GRAIL data showed, the position of the Moon's bulge shifts over time as the Moon librates about 7° East and West of its average orientation towards Earth.

- **Libration in longitude** results from the eccentricity of the Moon's orbit around Earth; the Moon's rotation sometimes leads and sometimes lags its orbital position.
- **Libration in latitude** results from a slight inclination between the Moon’s axis or rotation and the normal to the plane of its orbit around Earth" [http://en.wikipedia.org/wiki/Libration ]

**Scientists date Moon at 4.470 billion years – 95 million years after Earth**

April 2, 2014 – The Moon was formed about 95 (give or take 32) million years (after the birth of our Solar System, in a collision that also settled the structure of Earth as we know it, according to the latest attempt at dating that impact. Previous estimates had ranged from an "early" impact about 30 million years after the start of the Solar System, to a later one as much as 200 million years after.

The Solar System itself is known to be 4.567 billion years old thanks to accurate dating of some components of meteorites -- the oldest materials to be found on Earth. Earth is believed to have formed at some time during the first 150 million years. The impact event is also believed to have marked the final phase of Earth's core formation from molten metals sinking to the centre from a superhot surface.

A team of planetary scientists from France, Germany and the United States created a computer model of how dust and rock accumulated in the early Solar System to form tiny planets called planetesimals. These grew into “planetary embryos” that ended up as the rocky planets we know today -- Mercury, Venus, Earth and Mars -- through a succession of giant impacts, according to the new model.
Each massive collision allowed the planets to "accrete" or accumulate matter. In Earth's case, the lunar impact would have marked its final major growth event.

The team also determined the amount of material the planet accumulated after the grazing impact -- only about 0.5 percent of its total mass. The evidence suggested Earth took 95 million years to form, "which confirms it as the planet in our Solar System that took the longest to form,"##

'Mark the Moon For Good' | X Prize Planetarium Show Trailer Video
http://www.space.com/25383-back-to-the-moon-for-good-x-prize-planetarium-show-trailer.html

First Broadband Wireless Connection ... to the Moon
http://www.spacedaily.com/reports/First_broadband_wireless_connection_to_the_moon_999.html

MAY 23, 2014 - If future generations were to live and work on the Moon, they would probably want a broadband connection to communicate with home bases back on Earth. They may even want to watch their favorite Earth-based TV shows.

That may now be possible. A team of researchers from the Massachusetts Institute of Technology's (MIT) Lincoln Laboratory, working with NASA, demonstrated for the first time last Fall that a data communication technology exists that can provide space dwellers with the connectivity we all enjoy here on Earth, enabling large data transfers and even high-definition video streaming.

June 8–13 San Jose, California, USA. The team will present new details and a comprehensive overview of the performance of their record-shattering laser-based communication uplink between the Moon and Earth. In a demonstration last fall, the previous record transmission speed was surpassed by a factor of 4,800. The team made history last year when their Lunar Laser Communication Demonstration (LLCD) transmitted data over the 384,000 km (238,000 mi) between the Moon and Earth at a download rate of 622 megabits per second, far faster than any radio frequency (RF) system.

Communicating at high data rates from Earth to the Moon with laser beams is challenging because of the 400,000-kilometer distance spreading out the light beam, It's even more difficult going through the atmosphere, because air turbulence can bend light--causing rapid fading or dropouts of the signal at the receiver. To overcome this problem, the demonstration uses several techniques to achieve error-free performance over a wide range of optically challenging atmospheric conditions in both darkness and bright sunlight.

A ground terminal at White Sands, New Mexico, uses four separate telescopes to send the uplink signal to the Moon. Each telescope is about 6 inches in diameter and fed by a laser transmitter that sends information coded as pulses of invisible infrared light. The total transmitter power is the sum of the four separate transmitters, which results in 40 watts of power. Each telescope transmits light through a different column of air that experiences different bending effects from the atmosphere.

This receiver uses a slightly narrower telescope to collect the light, which is then focused into an optical fiber similar to fibers used in terrestrial fiber optic networks. From there, the signal in the fiber is amplified about 30,000 times. A photodetector converts the pulses of light into electrical pulses that are in turn converted into data bit patterns that carry the transmitted message. Of the 40–watt signals sent by the transmitter, less than a billionth of a watt is received at the satellite--but that's still about 10 times the signal necessary to achieve error-free communication.

Their CLEO: 2014 presentation will also describe how the large margins in received signal level can allow the system to operate through partly transparent thin clouds in the Earth's atmosphere, which the team views as a big bonus.

The team predicts that it's also extendable to deep-space missions to Mars and the outer planets.

Editor: We wonder if signal spreading over such vastly greater distances would be a problem. ##

THE MOON – COMMERCIAL MISSIONS

Google Lunar X-prize 2015 Lunar Landing Race Will Be Televised

A new generation may see a moon landing broadcast on live TV in the next couple of years. Several teams of engineers are rushing to put a robotic spacecraft on the Moon before the end of 2015 in the Google Lunar X-Prize competition, which is offering up to $30 million in prize money for the feat.
The Science Channel and Discovery Channel will cover the moon race, from testing to liftoff, to a new generation that may see a Moon landing broadcast on live TV in the next couple of years. This will engage the public around this milestone event, creating an ‘Apollo Moment’ for the next generation.

In addition to the technological breakthroughs catalyzed by the Google Lunar X Prize, an equally important goal is to inspire young scientists, engineers and space explorers. “More than half the world’s population has never had the opportunity to experience a live broadcast from the Moon. Partnering with Discovery Channel and Science Channel will allow us to engage the public around this milestone event, creating an ‘Apollo Moment’ for the next generation.”

To win the $30 million in main Google Lunar X Prize, privately funded teams must be the first to successfully land a robot on the surface of the Moon, have it travel at least 500 meters (1,650 feet) and send video, images and data back to Earth. Teams must complete these goals Dec. 31, 2015 to have a shot at taking home the overall prize. The purpose of the competition is to stimulate innovation, spur the development of lunar resources and advance private spaceflight technology.

The groups also have a chance to win smaller bonus prizes of up to $1 million if they complete certain milestones, such as creating the hardware and software that would enable a soft landing on the Moon. For the list of Teams, check [http://www.googlelunarxprize.org/teams](http://www.googlelunarxprize.org/teams) (those grayed out have dropped out of the competition.)

Eileen O’Neill, group vice–president for Discovery Channel, Science Channel and Velocity, said "When the winning craft touches down on the moon’s surface, it's going to trigger buzz and inspiration all over the world.” ##

**Astrobotic Partners With NASA To Develop Robotic Lunar Landing Capability**


May 05, 2014 – **Astrobotic Technology** has announced a new partnership with the National Aeronautics and Space Administration (NASA) for development of robotic lunar landing capability. The company has been selected as a partner under NASA’s new Lunar Cargo Transportation and Landing by Soft Touchdown (Lunar CATALYST) initiative. NASA’s call for proposals sought partners in the development of reliable and cost–effective commercial robotic lunar lander capabilities that will enable the delivery of payloads to the surface of the Moon. Such partnerships could support science and exploration objectives, such as sample returns, geophysical network deployment, resource prospecting, and technology demonstrations. The technology advances made by the various teams contending for the Google Lunar X–Prize have shown that small but effective instrument payloads can be landed on the Moon for much less money.

"Moon landing once symbolized the pinnacle of human achievement," said William "Red" Whittaker, Astrobotic’s Chairman. "CATALYST now evolves that to enterprise and to the remarkable capability that is possible through this public–private partnership. CATALYST will build a bright future combining a mix of new resourcefulness with legacy and innovation.

Astrobotic was selected by a panel of experts from NASA based on its proposal to develop a commercially viable lunar cargo delivery capability. Proposals were judged on the achievability of lander development and performance, and likelihood of success. Astrobotic will now negotiate a Space Act Agreement with NASA that makes personnel, facilities, and expertise available to the company to support its lunar lander development. Modeled after the highly successful Commercial Orbital Transportation Services program, this new collaboration will extend the reach of commercial capabilities to the Moon.
Astrobotic is making it possible to buy lunar delivery and utility services at a fraction of the cost. Together with NASA, we will create a new era that makes space available to everyone."

We will now see an era of much more lunar science accomplished in an affordable way. 

'Moonhouse' Crowdfunding Project to Build 1st Art Show on the Moon

The Moonhouse Project: An Art House on the Moon (Images)

http://www.space.com/26031-moonhouse-project-moon-art-installation.html
http://www.space.com/26030-moonhouse-art-project-moon-images.html

May 28, 2014 – The artistic minds behind a crowdfunding project want to land a small red house on the Moon, as the first-ever piece of art on the lunar surface.

Artist Mikael Genberg and others involved with the Swedish effort want to place a robotic, self-assembling, red house on the Moon by late 2015 atop a Space-X's Falcon 9 rocket along with Astrobotic's private Moon rover competing for the $200 million Google Lunar X-Prize.

First, the Moonhouse project needs help from people via a crowdfunding attempt to raise more than $15 million in the next six months.

A house on the Moon

The Moonhouse is designed to make the trip folded up in a shoebox-sized package. After it is placed on the lunar surface, the art installation will unfold and self-assemble as an 2.5 meters tall (8 ft) red house with white corners, a traditional design for many Swedish homes. It should take from 5 to 15 minutes for the Moonhouse to self-assemble.

Representatives with Astrobotic are planning on monitoring the assembly of the Moonhouse from the lunar surface using high-definition video cameras. At the moment, Astrobotic's first destination is an area of the Moon called Lacus Mortis [area in red circle in image below]. This particular part of the lunar surface harbors a special feature called a "moon pit," which could actually be an entry to a network of subsurface lava tubes that could someday shelter human settlers from radiation, micrometeorite impacts and extreme temperature fluctuations. What better place to land the Moonhouse than right next to place where people could settle for a long time in the future.

Crowdfunding to the Moon

Moonhouse representatives have set up a series of prizes for people that contribute to the crowdfunding effort online. Contributors that spend $30 will gain access to a 3D drawing of the Moonhouse that can be printed using a 3D printer. People that pledge $50 will actually get their names engraved inside the real Moonhouse that will self-assemble on the lunar surface.
To learn more about the project and to help fund the lunar art installation, visit the Moonhouse website: http://themoonhouse.com/en

THE MOON - HUMAN MISSIONS

China unveils Prototype of its planned Manned Moon Rover

http://www.ecns.cn/cns-wire/2014/04-10/108851.shtml

April 10, 2014 – (ECNS) -- China's self-developed manned moon rover made its first appearance at the 11th China Chongqing Hi-tech Fair on Thursday. Similar in size to a sport-utility vehicle, the vehicle has been developed by a research team of experts from 27 Chinese key universities.

The rover is big enough to hold two astronauts, and can carry several tools. The frames are made of hi-tech light and unbreakable materials. The rover is big enough to hold two astronauts, and can carry several tools. With a collapsible design, the rover can be folded and placed inside a manned rocket.

Just a prototype, it's design and development yet to be finished, the rover features dummy wheels of plastic foam. The real wheels and some other parts of the vehicle are being kept confidential. The vehicle is expected to be finished in 2015. ##

Human Lunar Missions Subject of Debate at Exploration Workshop

NASA and ESA disagree on best plan


[By Jeff Faust] April 11, 2014 – LAUREL, Md. — A dozen space agencies, including NASA, have agreed upon a Global Exploration Roadmap that lays out general plans for human missions leading up to Mars. But an April 10 workshop revealed continued disagreement on the best way to get there, particularly regarding the role of human missions to the Moon's surface.

The NASA Community Workshop on the Global Exploration Roadmap, held at the Applied Physics Laboratory here, brought together representatives from NASA, industry and other space agencies to discuss the updated version of the roadmap that outlined pathways for human exploration leading to humans on the surface of Mars.

"We all agree that, as a common, long-term goal, humans on the surface of Mars is something we all strive for," NASA's Roland Martinez, one of the meeting organizers, said in an opening presentation at the workshop. He added there was also strong support for using the international space station as a starting point in those exploration plans.

In between the ISS and Mars, the report identifies three "mission themes" for missions that eventually lead to Mars:

- Missions to near-Earth asteroids,
- Missions to the vicinity of the Moon
- Missions to the surface of the Moon.

The sequence and schedule of missions in those three areas remains unclear. NASA is not interested in pursuing humans to the surface of the Moon. Instead, NASA plans to move on from the ISS with its Asteroid Redirect Mission and, later, as-yet-undefined deep-space missions before going to Mars.
Others at the workshop argued that human missions to the lunar surface are essential to eventually sending humans to Mars. “If you want to get to Mars with human beings, you’ve got to go to the Moon first so you can learn how to live and work on another planet.”

Bernhard Hufenbach of the European Space Agency’s European Space Research and Technology Centre, argued “I don’t think you can do missions to deep space, the lunar vicinity, or asteroids for a period of 20 years without sending humans to a planetary body like the lunar surface,” he said. “It will not be inspiring enough. You will not keep the public engaged.”

A NASA authorization bill approved April 9 by the House Science Committee’s space subcommittee would require NASA to develop an “Exploration Roadmap” that includes “the specific capabilities and technologies necessary to extend human presence to the surface of Mars and the sets and sequences of missions required to demonstrate such capabilities and technologies.” That roadmap would be due to Congress 180 days after the bill’s enactment.

Russia plans to Establish a Human Foothold on the Moon

April 15, 2014 – Russia plans to build a permanent base on the Moon rather than abandon it after several successful manned missions, now in the planning stages. The Russian deputy defense minister in charge of defense and space industries said.

“The Moon is not an intermediate point in the [space] race, it is a separate, even a self-contained goal. It would hardly be rational to make some ten or twenty flights to the Moon, and then wind it all up and fly to the Mars or some asteroids. This process has the beginning, but has no end: we are going to come to the Moon forever,”

– Dmitry Rogozin in an article published by the government daily Rossiiskaya Gazeta.

A mission to the Moon has become one of Russia's top space priorities.

Roscosmos has launched a project to design a spacecraft suitable for Moon missions and a super-heavy carrier rocket to deliver it there.

Russia plans to launch three unmanned lunar spacecraft – two landers and one orbiter – by the end of the decade. The first mission, the long-delayed Luna-25, is slated to launch in 2016 and land at the Moon's south pole. The next two missions will include an orbiter to monitor the Moon in 2018 and a polar lander with a drill to search for water ice in 2019.

By 2040, Russia plans to create a lunar base for long-term missions.

“The Moon is the only realistic source to obtain water, minerals and other resources for future space missions, as well as a suitable platform for testing new space technologies.” Russia's plans to engage in search and exploration of natural resources in our solar system and beyond.

"We should not be afraid to dream, to raise the bar as high as possible for our future development. Russia has everything needed for a new breakthrough in space research. All we need is to learn how to combine idealism and pragmatism and how to properly organize our business,”

[Editor.: Russia does not have to deal with Congressional Politics, the height of irrationality.]

Russia Eyes Soyuz Upgrades for Mission Around the Moon


Space tourism firm Space Adventures says two customers have paid deposits for a flight around the Moon on a Soyuz spacecraft, but to get Soyuz ready for a lunar voyage requires major changes to the Russian crew capsule, a vehicle that has seen only incremental upgrades in recent decades.

While the Virginia–based company works with Russian engineers to ready the craft for a lunar voyage, prices for tourist trips to the International Space Station should fall once U.S.–built commercial capsules begin flying astronauts into low Earth orbit.

The flight around the Moon goes for $150 million per person, and a seat on a Soyuz mission to the space station is priced at $52 million. The lunar mission would carry a crew commanded by a professional Russian cosmonaut. Two paying passengers would make for a $300 million mission. Energia plans to modify the spacecraft’s the ship's communications and navigation systems for the Moon mission.

They need to change the heat shield because a craft returning from the Moon would be re-entering Earth’s atmosphere at a significantly higher speed. Engineers are considering whether to guide the Soyuz landing capsule to a "skip re-entry" in which the spacecraft would dip into the atmosphere
to dissipate speed before plunging to the surface to a parachute-assisted touchdown. The Soviet-era Zond robotic circumlunar missions, intended to pave the way for future human voyages, pioneered the skip re-entry technique in the 1960s.

The Soyuz also needs a new habitation module to give the crew more living space during the week-long trip from Earth to the Moon and back.

The probable flight plan calls for the Moon-bound crew to fly to the space station on a Soyuz rocket and spacecraft for a few days, then undock and rendezvous with a habitation module and Block DM propulsion stage launched separately atop a Proton booster. The Block DM engine would propel the Soyuz capsule on a trajectory once around the far side of the Moon and back to Earth. If the flight includes a visit to the space station, the mission's total duration will be about 17 days. An unmanned lunar flight is planned before Russian launches a piloted mission, and the earliest opportunity for a tourist trip is late 2017 or in 2018. If there is sufficient demand, Space Adventures and Energia plan a series of lunar expeditions.

## NASA's Plan To Deal With Pesky Moon (and Mars) Dust

By Jeremy Hsu – December 25, 2013  [not abridged nor paraphrased by TTS Editor]


[This article originally appeared in the January 2014 issue of Popular Science]

The Problem: Moon dust is dangerous.

Each mote is like a tiny shard of glass—there's no wind or rain to soften the edges of lunar soil. During the Apollo missions, it jammed equipment and got stuck in the seals of space suits, causing a serious loss of pressure. Martian dust poses its own hazards. There, swirling dust storms have covered rovers' solar panels, significantly reducing their power while they waited for a favorable gust of wind. And if these kinds of space dust get into an airlock, forget it: It can be toxic or irritating to the lungs and could endanger astronauts' health on long missions.

The Solution

An electric charge can zap the stuff right off. NASA scientists proposed the idea in a 1967 paper, but the space agency didn't return to it until 2003, when Carlos Calle and colleagues at NASA's Kennedy Space Center in Florida considered building the technology into Mars rovers. Running mere milliwatts of power through thin wires creates electric fields that cleared away 99 percent of dust in simulated lunar and Martian conditions. The team tested wires of different materials embedded in various surfaces. Transparent indium–tin–oxide wires protected solar panels; aluminum or silver wires worked for reflective films that shield rovers and landers from excess heat and sunlight; copper wires were effective beneath white, heat–reflecting thermal paint. They've also tested conductive carbon–nanotube inks on cotton and will try them on space–suit fabrics. In 2016, NASA will finally begin testing the dust shields in space.

## Radio Dishes Peer Beneath Moon's Surface (Images)

http://www.space.com/25884--radar-telescopes-moon-subsurface-features.html

This image reveals previously hidden features around an area known as Mare Serenitatis, or the Sea of Serenity, which is near the Apollo 17 landing site. – Full size image:

http://i.space.com/images/i/000/039/306/original/craters2labeled_nrao.jpg?1400124864
May 15, 2014 – Two huge radio telescopes have given scientists a rare look beneath the surface of the Moon. Signals beamed from the Arecibo Observatory in Puerto Rico — with a diameter of 305 m (1,000 ft) — penetrated deep into the Moon. They then bounced back and were detected by the Green Bank Telescope. This technique, called bistatic radar, is used to study many objects in our solar system. In this case, it revealed subsurface details in two lunar locales, the Sea of Serenity and a crater called Aristillus. The new radar observations allow scientists to peer 10 to 15 m (33 to 50 ft) beneath the Sea of Serenity, which is near the site where NASA's final manned lunar effort, the Apollo 17 mission, touched down in December 1972. Light and dark areas visible in the image reveal details of rock and dust composition. The radar images also provide a new perspective on Aristillus crater, which is about 55 kilometers (34 miles) wide and 2.2 miles (3.5 km) deep.

The dark 'halo' surrounding the crater is due to pulverized debris beyond the rugged, radar-bright rim deposits. The image also shows traces of lava-like features produced when lunar rock melted from the heat of the impact.

Peering beneath the Moon's dusty surface may help scientists better understand the Moon’s history and evolution and also improve our knowledge about previous lunar landing sites and help mission planners pick sites for future moon–exploration efforts.

3 Private Moon Lander Concepts Make NASA's Short List
http://www.space.com/25935-private-moon-landers-nasa-lunar-catalyst.html

May 19, 2014 – NASA has shortlisted three potential commercial partners for non-funded agreements as part of the agency's quest to land robotic spacecraft on the Moon. The companies — Astrobotic Technology Inc., Masten Space Systems Inc. and Moon Express Inc. — will now proceed to the next stage of negotiations for the Lunar Cargo Transportation and Landing by Soft Touchdown (Lunar CATALYST) initiative.

While NASA will not provide money, the agency is prepared to offered assistance in technical matters, access to test facilities, equipment loans and software for three years. The ultimate goal would be bringing scientific experiments to the Moon's surface.

Left: Masten's XEUS lander for NASA's Lunar CATALYST project.
Right: Astrobotic Technology’s Grif – Credit: Astrobotic Technology Inc.

“Robotic missions to the Moon have revealed the existence of local resources, including oxygen and water, which may be highly valuable for exploration of the solar system. The potential to use the lunar surface in partnership with our international and commercial partners may allow these resources to be characterized and used to enable future exploration and pioneering,”

When the project was first announced in January, NASA said it expects Lunar Catalyst will let companies do commercial endeavors such as Moon mining, while advancing science and technology. The agency also believes it could help prepare for deeper-space missions such as a voyage to Mars.

Both Astrobotic and Moon Express are competing for the $30 million Google Lunar X Prize awarded to a private team that can land and perform activities on the surface of the moon by Dec. 31, 2015.

NASA Funds 12 Futuristic Space Tech Concepts:
1 Moon–related: Exploring Lavatube “Skylights” from orbit

PERISCOPE: PERIapsis Subsurface Cave OPTical Explorer (Jeffrey Nosanov, JPL)
http://www.nasa.gov/content/periscope-periapsis-subsurface-cave-optical-explorer/

Lunar sub–surface exploration has been a topic of discussion since the Lunar Reconnaissance Orbiter
identified openings (lava tube cave skylights) on the surface of the moon in 2009. NASA’s participation in the UK’s MoonLITE mission shows the wide appeal of this phenomenon.

NASA has focused internally on two distinct architectures to explore the lunar sub-surface: robotic (rover based) or human (astronaut based). Both are unfortunately beyond the limits of NASA’s conceivable near- and mid-term resource allocation.

We present a third option: mapping and characterization of lunar subsurface structures with an orbiting platform performing photon time-of-flight imaging. A tabletop demonstration of the imaging technique, “seeing around corners” was led by one of the authors and we assert that this concept can be extended to a lunar orbiting platform architecture.

---

**THE MOON – TOTAL LUNAR ECLIPSE**

**Moon Turns Red – Lunar Eclipse Time-Lapse Video**


Once lunar tourism begins, being “on location” for a total Lunar Eclipse will be “as best as it gets” as the lunar surface takes on the hues of Mars at twilight.

**Experiencing Eclipses on the Moon**

Every now and then, Earth-facing moonscapes take on the hues of a dimly lit Mars. But there will be no mistaking where you are. In the sky in place of Earth will be a black hole outlined with a ring of orange tones with only one ten thousandth the brilliance of sunlight. And in that black hole, clusters of lights, Earth’s cities and fires, dotting otherwise dark continents. It is “Umbra.”

NEAR SPACE TOURISM

Virgin Galactic Signs FAA Deal to Clear Airspace for Suborbital Flights

Virgin Galactic, the private space venture bankrolled by billionaire Sir Richard Branson, has signed an agreement with the Federal Aviation Administration (FAA) that spells out how the company will use U.S. airspace during its planned suborbital flights.

The company hopes to begin commercial flights aboard SpaceShipTwo out of New Mexico's Spaceport America in the next 7 months, by the end of 2014.

The deal outlines how Virgin Galactic will work with the FAA's air traffic control center Albuquerque and the New Mexico Spaceport Authority to safely provide clear airspace for SpaceShip Two.


Virgin Galactic is the anchor tenant at Spaceport America and it began paying rent on a 20-year lease to conduct missions from the "Gateway to Space" building at the remote spaceport near Truth or Consequences, New Mexico, just west of the White Sands Missile Range.

The company already has agreements in place with Edwards Air Force Base and the FAA's Joshua air traffic control center to cover their test flights in California.

SpaceShipTwo can seat two pilots and six passengers. It is designed to be carried by a mothership plane called WhiteKnightTwo. Once the linked vehicles reach an altitude of about 15,000 meters (50,000 ft), the spaceship is released and its rocket engine kicks in, launching it into suborbital space.

Passengers will get to climb out of their seats and experience weightlessness during the flight with a view of the curvature of Earth against the backdrop of black space.

So far, several hundred people have purchased seats, which currently cost about $250,000, for Virgin Galactic's future commercial flights. Celebrity ticket holders include Lady Gaga, Justin Beiber, Leonardo DiCaprio and Ashton Kutcher.

TOURISM TO AND ON THE MOON

Moon to see first tourists by 2017, single roundtrip ticket costs $150 mln

The Moon could welcome its first tourists as early as 2017, Space Adventures, a US-based space tourism company, said Wednesday. Two unnamed persons have agreed to spend a fortune on the tickets. They will pay $150 million dollars each.

The package includes training in the Mission Control Center in Russia's Star City, where all cosmonauts prepare for their missions. The adventure itself will start with a one-day tour around the ISS on board a Russian Soyuz spacecraft monitored by professional cosmonauts. Then comes the 17-day flight to the Moon and back.
Space Adventures describes the mission as the “good old deep space exploration,” as no human has left low earth orbit since the Apollo 17 mission of 1972, which was NASA’s final flight to the Moon.

"Mankind can only progress to become a space faring race by taking the small steps necessary to reduce the costs of access to space. This mission will be one of those small, but very significant steps."

The Soyuz vehicle, designed for a Soviet mission to the Moon in the late 1960s and early 1970s, has never flown beyond low Earth orbit. "We can do this – circle the moon in 2017 to 2018 on Soyuz. Space Adventures is now arranging a flight for British singer Sarah Brightman that is scheduled for 2015.

**TOURISM TO AND ON MARS**

**Putting Humans on Mars Is 'Risk Management' for Our Species – Elon Musk**


June 5, 2014 – SpaceX's manned Dragon spacecraft could make a human colony on Mars possible


June 05, 2014 – SpaceX thinks humanity needs to reach Mars to survive. Manned exploration and the eventual colonization of Mars would not only be a marvel of human achievement, it would also serve as a sort of insurance in case disaster strikes on Earth, SpaceX president Gwynne Shotwell told a small crowd.

"Exploration is really what separates humans from other living species. If we decide that where we are today is 'it,' that seems like a big disappointment."

If humans decided to stop exploring, saying, "This is it, we're done," that's not very inspirational, Shotwell said. But exploration isn't the only reason to visit the Earth's rouge neighbor. Creating a settlement on Mars also constitutes "risk management" for the human race, Shotwell said. "The probability of a significant [disastrous] event happening on Earth is very high," Shotwell said. Though she said she doesn't know when it might happen, "it would be nice to have humans living in more than one spot."

**Elon Musk plans to take people to Mars within 10 years**

www.space-travel.com/reports/Elon_Musk_plans_to_take_people_to_Mars_within_10_years_999.html

June 24, 2014 – Entrepreneur and inventor Elon Musk has some travel suggestions that are out of this world. The SpaceX CEO wants to take humans to Mars during the next decade. His main goal at this moment is to perfect technology that would make space travel possible in the not-so-distant future.

In less than 12 years' time, Musk wants to make the red planet a must-stop travel destination for interstellar tourists. "I'm hopeful that the first people could be taken to Mars in 10 to 12 years, I think it's certainly possible for that to occur. But the thing that matters long term is to have a self-sustaining city on Mars, to make life multi-planetary."

Another long term issue is raising the capital that's required to make both visiting and inhabiting Mars an obtainable goal. Musk’s 10-year plan is already too long-term to attract hedge fund managers willing to invest, but at this rate that could soon change.

"We need to get where things are steady and predictable, Maybe we're close to developing the Mars vehicle, or ideally we've flown it a few times, then I think going public would make more sense."

"Since 1989, when a study estimated that a manned mission would cost $500 billion, the subject has been toxic. Politicians didn't want a high-priced federal program like that to be used as a political weapon against them. But the United States is a nation of explorers. America is the spirit of human exploration distilled."
MARS ANALOG EXERCISES

'MarsFest' Gives Public a Glimpse at Science in the Marslike Death Valley

[Links to full articles]

April 25, 2014 – DEATH VALLEY, Calif. — As Susanne Douglas showed a group of visitors examples of microbial life of the type that might exist on Mars, she was asked whether humans or robots would be most likely to find indigenous Martians — if they exist.

"If it wasn't a suicide mission to go to Mars, I think I would probably take the person," Douglas responded. "Maybe one day it will not be a suicide mission. But I think the robots are doing a darn good job."

Human trips to the Red Planet are likely several decades away. So Douglas, a geomicrobiologist with the Planetary Science Institute in Tucson, Ariz., studies life at a Mars-like environment on Earth: the salt flats and shallow ponds of Badwater Basin, located 282 ft (86 m) below sea level here in California's Death Valley National Park.

On this particular Saturday in late March, Douglas was leading a field trip to Badwater as part of MarsFest, a weekend-long outreach event that gave the general public a look at the analog research work being done by scientists in Death Valley.

Left: Explaining the history of Ubehebe Crater in Death Valley National Park.

Center: Ubehebe Crater in Death Valley is used to understand conditions in Gale Crater on Mars

Right: A sample of microbial life that thrives in the harsh environments of Badwater Basin.

The third annual gathering was co-sponsored by The SETI (Search for Extraterrestrial Intelligence) Institute, the National Park Service and three NASA field centers — Ames, Goddard and the Jet Propulsion Laboratory. The event drew more than 500 participants, and featured field trips to three different analog locations in the park as well as lectures at the Furnace Creek Visitors Center by Dr. Chris McKay of NASA Ames and other leading Mars experts.

In addition to detailed tours of some of Death Valley's most interesting geological features by experts who study them for a living, there were also informal dinners with the scientists at the Corkscrew Saloon. Participants who camped out in the park also got an unobstructed view of the Milky Way at night under Death Valley's clear skies.

Death Valley offers sites that are analogs to Mars' Gale Crater, which the Curiosity rover is now exploring. MarsFest participants also toured the Mesquite Sand Dunes, similar to the ones on Mars.

The final field trip on Sunday morning was to Ubehebe Crater, on the north end of the park. Participants trekked down to the bottom of the crater, 183m (600 ft) deep and 0.8 km (0.5 m) around at the rim.

Organizers were pleased with this year's MarsFest gathering. ##
Mars on Earth: Vacuum Chambers mimic the Red Planet

March 25, 2014 – Scientists have built Mars here on Earth within the walls of a simulation chamber that mimics conditions on the Red Planet down to its Martian dust. Spanish researchers have built a vacuum chamber to reproduce conditions including temperature, pressure, gas composition and radiation on Mars, to help test gear designed for missions to Mars. Such chambers have already been used to test some of the weather sensors aboard Curiosity.

Lead researcher Jose Angel Martin–Gago, of Madrid's Instituto de Ciencias de Materiales and his team is collaborating with NASA, in helping develop meteorological instruments for upcoming rovers. In addition to the Mars simulator, the team has also built vacuum chambers mimicking the environments on other planets and on Europa, one of Jupiter's icy moons, as well as the space between stars and between planets.

Why is Mars so much smaller than Earth?

May 1, 2014 – Mars surface area (all dry land) is similar in area to all Earth’s continents together, minus oceans

Mars has about 10% of Earth’s mass and 38% of Earth’s gravity.

New ideas about how the solar system took shape are helping astronomers tackle a planetary puzzle — why Mars is so much smaller than its rocky neighbor worlds. Models show that if gas and dust had been distributed relatively smoothly throughout the protoplanetary disk that surrounded the newborn sun 4.5 billion years ago, Mars would be about as big as Venus and Earth. But Mars has just 10% as much mass as either sister world, suggesting that it formed in a region relatively depleted of planet-forming material. The leading theory behind this depletion has been something called the Grand Tack model.

Two different theories why Mars is just 10% as massive as Earth and Venus

Left: If the solar nebula (shown in pink) had a partial gap near Mars' orbit, the growth of solid bodies would have been less effective, reducing final mass of Mars while allowing Earth and Venus to grow larger. Separate events then depleted the asteroid belt.
Right: In the Grand Tack model, Jupiter's orbit crossed the asteroid belt twice, removing most planetary building blocks from the region beyond Earth's orbit and reducing the mass of Mars and the asteroids.

The Grand Tack idea holds that Jupiter and Saturn migrated toward the Sun shortly after they formed, then headed back out toward the outer solar system once again after sweeping away lots of material from the area where Mars would form, stunting Mars' growth but not that of Earth and Venus.

The Natural Gap idea of researchers from the Universidade Estadual Paulista in Brazil, proposed an alternative idea in a paper published in February in The Astrophysical Journal. Simulations of gas flow in the solar system's early days suggest that a low-density region may have naturally existed in the protoplanetary disk between 1 and 3 AU from the Sun. If this partial gap survived long enough, it could have been preserved in the distribution of planetesimals and planetary embryos that formed subsequently. The simulations performed by Izidoro show that reducing the number of planetary building blocks near Mars' current orbit by 50 to 75 percent favors the formation of a puny Red Planet.

Interestingly, both of these ideas — Grand Tack and Natural Gap — posit that Mars first began taking shape at around 1 AU, near Earth's present orbit. Gravitational interactions then pushed proto-Mars outward to its current location, where the lack of raw material stunted its growth.

It may be possible to determine which of these two scenarios more accurately depicts reality. For example, the idea presented by Izidoro and his team predicts that asteroids in the main belt between Mars and Jupiter coalesced pretty much where they sit today.

"In the Grand Tack model, the asteroid belt was purged at a very early stage, and the surviving members sample a much larger region of the solar nebula. These differences may help us distinguish between the models in future."

But it is possible that neither model is accurate. ##

Target on Mars Looks Good for NASA Drilling by Opportunity Rover

http://www.marsdaily.com/reports/Target_on_Mars_Looks_Good_for_NASA_Rover_Drilling_999.html

May 1, 2014 – The team operating NASA's Curiosity Mars rover plans to proceed with the third drilling into a rock on Mars to collect a sample for analysis. The rover used several tools to examine the candidate site, including a wire-bristle brush -- the Dust Removal Tool -- to clear away dust from a patch on the rock. The target slab has been given the informal name "Windjana," after a gorge in Western Australia.

http://photojournal.jpl.nasa.gov/archive/PIA18088.gif

Martian Sandstone Target "Windjana" Before and After Brushing: This two-step animation shows before and after views of a patch of sandstone scrubbed with the Dust Removal Tool, a wire-bristle brush, on NASA's Curiosity Mars rover. Both images were taken April 26, 2014, by the Mars Hand Lens Imager on Curiosity's arm. The target rock is called "Windjana."

"In the brushed spot, we can see that the rock is fine-grained, its true color is much grayer than the surface dust, and some portions of the rock are harder than others, creating the interesting bumpy textures. All of these traits reinforce our interest in drilling here in order understand the chemistry of the fluids that bound these grains together to form the rock."

Before Curiosity drills deeply enough for collection of rock-powder sample, plans call for a preparatory "mini-drill" operation on the target, as a further check for readiness. Curiosity's hammering
drill collects powdered sample material from the interior of a rock, and then the rover prepares and delivers portions of the sample to laboratory instruments onboard. The first two Martian rocks drilled and analyzed this way were mudstone slabs neighboring each other in Yellowknife Bay, about 4 km (2.5 mi) NE of the rover's current location at a waypoint called "The Kimberley." Those two rocks yielded evidence last year of an ancient lakebed environment with key chemical elements and a chemical energy source that provided conditions billions of years ago favorable for microbial life. ##

**Opportunity In Search Of Aluminum-Hydroxyl Clays**


May 14, 2014 – Opportunity is exploring south of 'Solander Point' on the west rim of Endeavour Crater. The rover is approaching a region of aluminum–hydroxyl clay minerals detected from orbit.

On Sol 3650 (May 1, 2014), With Opportunity conveniently near a ripple crest, it performed a touch-and-go activity with the robotic arm. The arm's microscopic imager (MI) acquired images for a mosaic, then its alpha particle X-ray spectrometer (APXS) was placed for an overnight integration. On the next sol, Opportunity drove southwest into the region expected to have clay minerals.

**Spacecraft-Riding Microbes Could Colonize Mars, Research Suggests**


Microorganisms from Earth could hitch a ride on spacecraft and end up colonizing Mars and other bodies in the solar system, recent research suggests. This has implications for the search for life: If Earth's microbes can survive the perilous journey to other planets and moons, it may be difficult to determine whether any microbial life discovered on those bodies originated there or was introduced from Earth.

To ensure space missions don't accidentally transfer microbes to other cosmic bodies, spacecraft are currently allowed to harbor only a certain level of microbial life, called the "bioburden," based on tests of how resistant different microbes are to intense radiation and other dangers of space travel.

Research in three studies published in the journal Astrobiology in 2012 suggest that the current bioburden standard isn't set high enough, because some microbes are far harder than expected. In two of the studies, scientists tested the ability of the spore-forming bacterium Bacillus pumilus SAFR-032 — with a high resistance to the ultraviolet radiation and peroxide used to clean spacecraft — to survive in space. Using the European Technology Exposure Facility (EuTEF) mounted on the International Space Station, scientists exposed the bacteria to a simulated Mars atmosphere. They also subjected the bacteria to various space conditions such as space vacuum, solar radiation and intense temperature fluctuations. Some of the spores survived for 18 months.
Surviving B. pumilus SAFR-032 spores also demonstrated elevated levels of proteins associated with UV resistance. Given that UV radiation is a big threat to space–living bacteria, the researchers believe that spores sheltered from solar radiation, such as those living under spacecraft structures, or mutant subpopulations with heightened UV protection, could possibly survive a trip to Mars.

In the third study, he survivability of rock–colonizing cellular organisms on the EuTEF were tested. Some of the organisms lasted the full 18 months in space.

The results suggest that rocks ejected from a planet due to a meteor impact could possibly carry rock–colonizing organisms to other planets (though it would take thousands to millions of years for the rocks to reach another planet).

---

**Curiosity Rover may have transported Earth Bacteria to Mars**

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

Mars Curiosity rover may have transported Earth bacteria to Mars 999.html

May 23–2014 – NASA’s Curiosity rover supposedly brought only cameras, sensors, and scientific equipment to Mars in August 2012. But it may have brought along dozens of species of bacteria that originated on Earth, according to a new study conducted by the American Society for Microbiology and published in the Nature science journal which revealed that 377 strains of bacteria may have survived the sterilization process that the Curiosity rover endured before it was launched in an attempt to avoid contaminating the red planet.

The bacteria may have survived the cleaning process than the revelation about the conditions they went through. Then, in transit to Mars, the microbes in question endured near-freezing temperatures and intense damage caused by ultra–C radiation, thought to be the most harmful type of radiation.

But it is still unclear whether organisms from Earth can survive and grow in a Martian environment where there is intense radiation, high oxidation potential, extreme desiccation, and limited nutrients.

"Knowing if microorganisms survive in conditions simulating those on the Martian surface is paramount to addressing whether these microorganisms could pose a risk to future challenging planetary protection missions."

Whether the bacteria spread to the Mars surface is unknown, although the very possibility has already made scientists concerned about unnaturally spreading life from Earth to Mars. There is already a United Nations Outer Space Treaty that aims to regulate how the increasingly advanced space programs from the international community explore the unknown. The parameters were first agreed upon in 1966 and they include, among others, the stipulation that

"States shall be liable for damage caused by their space objects;
and shall avoid harmful contamination of space and celestial bodies."

The limits vary depending on where the spacecraft lands. Mars, Europa, and other bodies that could potentially nurture life have a relatively strict standard of 300 bacterial spores per square meter. The goal is to keep the odds of contamination Mars (and other worlds) at less than 1 in 10,000.

"Up to 300,000 spores are allowed on the exposed surfaces of the landed spacecraft. That many spores would fit on the head of a large pin," said Laura Newlin, an engineer at NASA's Jet Propulsion Laboratory in California. "Currently our total spore count on the surface is comfortably under 200,000, so we're below the allowable level."

In an unrelated study, it was revealing that methanogens, the oldest organisms on Earth, could be the perfect candidate to foster Martian life. The University of Arkansas Fayetteville study determined that, because methanogens are non–photosynthetic and capable of living without oxygen, they are capable of living underground on Mars. [ http://en.wikipedia.org/wiki/Methanogen ]

The surface temperature of Mars varies widely, often ranging between -90° C and 27° C over one Martian day. If any life were to exist on Mars right now, it would have to at least survive that temperature range. The survival of these two methanogen species, exposed to long–term freeze thaw cycles, suggests methanogens could potentially inhabit the future of Mars."

---

**Could a Mars Volcano Be an Oasis for Life?**


Scientists are now focusing on a possible Martian oasis for microbial life where liquid water may have been stored underground and heated by a volcano. Geologists from Brown University have studied this fascinating possibility by focusing on Arsia Mons, a 16 k (10 mi) high ancient shield volcano that likely erupted during the Martian glacial period, melting surrounding glaciers and creating englacial lakes at the bottom of the volcano’s slopes.

Through analysis of data from Mars Reconnaissance Orbiter, researchers were able to identify features that were likely formed when the volcano erupted around 210 million years ago when glaciers were present. The heating from the eruption may have melted portions of the glaciers, trapping ‘bubbles’ of liquid water inside their glacial cocoons for long periods of time.

Where there’s liquid water (and therefore heat), life may have thrived. And what makes Arsia Mons really interesting is that this liquid water likely existed on the Martian surface in the relatively recent geologic past, potentially making this region a key target for future Mars life-hunting missions.

The slopes of Arsia Mons have long been of interest to geologists who speculated that there were likely large bodies of ice present when volcanoes were active. In 2003, Jim Head (Brown University) and David Marchant (Boston University) identified landforms around Arsia Mons that resembled the features left by receding glaciers in the Dry Valleys of Antarctica.

As glaciers recede on Earth, piles of rubble build up at the front of the ice, leaving a rocky ridge (a moraine) as a geological record of the limits of the glacier.

New models of Mars’ climatic past support the theory that glaciers may have been present in this equatorial location and studies of ancient lava flows appear to coincide around 210 million years ago. According to this research, all these factors could have supported liquid water “englacial” lakes for hundreds to thousands of years, possibly enough time for very basic life forms to evolve.

“There has been some work on Earth on the types of microbes that live in such englacial lakes. Subsurface masses of ice and pockets of liquid water may persist in the region today, only boosting the region’s candidacy for a dedicated life-hunting Mars mission. ##

---

**Mars Rover Curiosity Wraps Up Drilling Work, Prepares for Long Drive**


NASA's Mars rover Curiosity is about to hit the road again. The 1-ton rover has finished its drilling operations at the sandstone slab “Windjana,” collecting samples to its onboard scientific instruments for analysis. Then it will resume the long drive toward the base of Mount Sharp.

The rover bored a 6.4 cm (2.5 in) deep hole into Windjana earlier this month, its third full sample-collecting drilling activity since touching down inside Mars’ Gale Crater, August 2012.

Two previous drilling operations investigated fine-grained mudstones at a site called Yellowknife Bay, close to its landing site, had allowed mission scientists to determine that the Red Planet could have supported microbial life billions of years ago.

Mission scientists want Curiosity to climb up through these foothills, reading a history of the Red Planet’s changing environmental conditions as it goes. Data gathered on this long trek should shed light on why and when Mars changed from a relatively warm and wet planet to the cold and dry world we know today. ##
NEW MARS MISSIONS

How to Land on Mars with Inflatable Flying Saucers


April 28, 2014 – Less than two years after placing the 1-ton Curiosity rover gently on the Martian surface, NASA is already dreaming up ways to land even bigger spacecraft on the Red Planet.

Under development are gigantic supersonic parachutes and lightweight, saucer-like inflatable “decelerators” that will slow the descent of heavy gear through the thin Martian atmosphere, thus allowing large objects — such as human habitat modules — to make it to the planet's surface in one piece. This is not an entirely new idea, but builds on the concept of inflatable “ballutes” to decelerate through an atmosphere. By combining these technologies, we should be able to design craft considerably larger than Curiosity-size payloads including manned landing craft and habitat modules.

Ian Clark of NASA’s Jet Propulsion Laboratory in Pasadena, California, is the principal investigator for the agency’s Low-Density Supersonic Decelerator (LDSD) project.

NASA workers at the Jet Propulsion Laboratory, prepare the Low-Density Supersonic Decelerator (LDSD) test article for shipment to Hawaii. LDSD will help land bigger space payloads on Mars or return them back to Earth. Image Credit: NASA/JPL-Caltec

“We think these technologies are extensible for eventually being used to land even human-class payloads— things in the 10- to 15-ton range,” Clark told Space.com. "Not with the technologies themselves — perhaps clusters, multiple parachutes being used to generate just enormous amounts of drag that would be necessary for payloads of that class." The LDSD equipment could also be used to land payloads on other bodies with atmospheres, including Earth, (and Titan.) Thin Martian air

Putting a lander, rover or other piece of hardware down on Mars is tricky because of the planet's "in between" atmosphere, just 1 percent as dense as that of Earth: "too much air to rely solely on rockets to slow a craft's descent, but not enough to use just parachutes and air friction, as we do on Earth.

Curiosity hit the top of the Martian atmosphere going about 21,000 km/h (13,000 mph). Friction against the robot’s 4.5 m (15-ft)-wide aeroshell helped slow it down to about 1,400 km/h (900 mph), at which point the spacecraft deployed a parachute measuring 15.5 m (51 ft) across.

That still wasn't enough. Curiosity was finally lowered to the surface on cables by a rocket-powered “sky crane,” which flew away and crash-landed on purpose after getting the job done.

The success of Curiosity's landing in August 2012 validated this bold design, which will likely be used again on Mars. But payloads much bigger than Curiosity will require new equipment."If we want to go bigger, to higher elevations, and more accurately, we need technologies beyond what we currently have."

The LDSD project is developing a new 30.5 m (100-ft)-wide parachute, along with two balloon-like devices called Supersonic Inflatable Aerodynamic Decelerators (SIADs). One of these, called SIAD–R, is 20 feet (6 m) wide; the other, SIAD–E, measures 26 feet (8 m) across.
Each SIAD is designed to fit on the outer rim of an atmospheric entry vehicle. The device would inflate at speeds of about 4,280 km/h (2,660 mph), providing enough additional drag to slow down the spacecraft to around 2,445 km/h (1,520 mph), at which point the big supersonic parachute would be deployed.

This new gear could handle heavy loads, but it would still need some help from a sky crane or other device to slow down a payload to soft-landing speeds. The SIAD-R and big parachute weigh about 50 to 100 kilograms (110 to 220 lbs), respectively. Using them would allow a Curiosity-like mission to deliver about 1 additional ton to the Martian surface.

**NASA tests Mars Saucer**


June 28, 2014 - After several weather delays, NASA launched a helium balloon carrying the saucer-shaped vehicle high in Earth's atmosphere.

The first flight test for the LDSD project took place from the Pacific Missile Range Facility on the Hawaiian island of Kauai. A balloon carried the test vehicle equipped with SIAD-R and the big parachute to an altitude of 37 km (23 mi). A rocket on the vehicle then kicked on, taking it to supersonic speeds and an altitude of about 55 km (34 mi) where the thin air is a good analogue for the Martian atmosphere.

The SIAD-R and parachute then deployed in succession. Viewers around the world with an Internet connection followed portions of the mission in real time thanks to cameras on board the vehicle that beamed back low-resolution footage. At 33.5 meters (110 feet) in diameter, the parachute is twice as big as the one that carried the 1-ton Curiosity rover through the Martian atmosphere in 2011.

The test had been six previous times because of high winds. Winds need to be calm so that the balloon doesn't stray into no-fly zones. Two more stratospheric flight tests are on tap for next year. If all goes well, LDSD technology could make its way to Mars in the next decade or so. NASA wants its 2020 rover to gather and cache Martian samples for eventual return to Earth. The mission to retrieve those samples — whenever — will probably require the big chute and perhaps one of the SIADs.

Beyond that are human precursor-class missions — in the 2- to 3-ton range that may need a combination of a SIAD and a parachute. Clustering four or five LDSD parachutes together could help land even bigger payloads, perhaps paving “the way to put boots in Mars' red dirt.”

**Infographic on this new landing apparatus:** http://i.space.com/images/i/000/038/494/original/mars-landing-heavy-payloads-140414c-02.jpg?1397512045

**MAVEN Instrument Will Look at Key Player in Mars Atmosphere Loss**

http://www.marsdaily.com/reports/MAVEN_Solar_Wind_Ion_Analyzer_Will_Look_at_Key_Player_in_Mars_Atmosphere_Loss_999.html
http://www.nasa.gov/content/goddard/maven-on-track-to-carry-out-its-science-mission/


My 16, 2014 – On November 18th, NASA launched the Mars Atmosphere and Volatile Evolution (MAVEN) mission in the hope of understanding how and why the planet has been losing its atmosphere over billions of years. An instrument aboard the orbiter will study a special component of the Martian atmosphere. By studying ions, or small electrically charged particles, in and above Mar’s thin atmosphere, the Solar Wind Ion Analyzer will help answer why Mars has gradually lost much of its atmosphere.

MAVEN’s Solar Wind Ion Analyzer (SWIA) will spend much of its time measuring the ions in the solar wind which travels toward Mars at speeds around 600 thousand kph (one million mph), carrying a magnetic field that originates inside the sun. It is composed of charged particles that interact with neutral gas particles in Mars’ upper atmosphere, giving them the ability to escape from Mars’ gravitational pull.
Scientists think the interactions between solar wind ions and Mars' atmospheric particles are a key factor allowing the particles to escape, a process that gradually strips the planet of its atmosphere and has been doing so for billions of years.

Scientists could apply SWIA's measurements of solar wind ions with the measurements of the atmosphere's escaping gases the mission's other instruments make, making connections between the two that will paint the picture of how the atmosphere has evolved. SWIA will specifically be measuring the solar wind speed and density, two critical factors that determine how its ions interact with the planet's atmospheric particles. The solar wind's blazing speed ensures that a huge number of ions are hitting the Martian atmosphere, and interacting with the atmosphere's particles, every second.

By measuring the solar wind's density and velocity, SWIA could help determine whether gusts of denser, faster solar wind contribute to greater atmospheric loss. This information will be used to estimate losses in the past, when solar wind gusts may have been prevalent thanks to an early, more active sun. Once they hit the planet's atmosphere, the solar wind's ions play several critical roles in aiding particles to escape from Mars' atmosphere. Both ions and electrons could start the process of particle escape by transforming the atmosphere's neutral particles into charged ions. This can occur through charge exchange and impact ionization. Ultraviolet sunlight also transforms many atmospheric particles into ions. Once the atmospheric particles become charged, they can interact with the solar wind's magnetic field and be accelerated and carried away from the planet; the ionization step is critical, since the original neutral particles don't respond to the solar wind magnetic field and generally have too little energy to escape.

Although the solar wind ions are traveling at the same velocity as the electrons, they have a larger mass and thus, the solar wind ions are able to transfer more of the necessary momentum to the newly formed atmospheric ions themselves, providing them with more energy to escape.

MAVEN's principal investigator is based at the Laboratory for Atmospheric and Space Physics at University of Colorado, Boulder. The university provided science instruments and leads science operations, as well as education and public outreach, for the mission.##


New Mars InSight Lander to Probe Interior of Red Planet

May 29, 2014 – NASA, recently gave the green light for the construction of a new Mars lander that will examine the deep interior of the Red Planet. The new mission is called the **Interior Exploration Using Seismic Investigation Geodesy and Heat Transport**, acronym: **InSight**.

![Image of InSight Lander](image)

The spacecraft is scheduled to launch from California's Vandenberg Air Force Base in March 2016 and due to arrive on Mars in September. Some of the technology the lander will use to study the interior of Mars is similar to what geologists have been using to study the Earth. Its geophysical instruments, mostly a seismometer and a heat-flow probe are expected to help us better understand the interior structure of Mars, both its composition, layering, what's going on inside and provide a fresh look into the creation of our own planet but also other Earth–like planets located within and beyond our solar system.

The goal is a better understanding of how the terrestrial rocky planets formed early on in the solar system, and how that formation led to the kinds of conditions we have on the surface.

Unlike Curiosity and Opportunity, rovers that are traveling across Mars, InSight will be sent to a location near the Red Planet's equator and remain stationary to conduct its research and map out the geography of the deep Martian interior: how thick is the crust, what's the crust made out of? How big is the core, what is it made out of? What are the thermal characteristics of everything in terms of the heat flow, and energy production?
Multinational effort

The space agencies of Germany, France, Switzerland and the United Kingdom are providing two of the most important tools for the mission: (1) a seismometer that will measure and analyze seismic waves that shake the ground, mostly due to quakes; (2) a heat-flow probe that will burrow itself down about 4.5 to 5 meters beneath the planet's surface and measure small increases in temperature as it tunnels further into the crust of Mars and help us figure out how much heat is coming from the planet's interior.

"This heat flow is what drives a lot of the geology: it drives volcanism; on Mars, it can drive uplift of mountain ranges; and so the amount of heat coming out of it is a basic parameter that we need to learn in order to find out how active a planet is."

One important tool that will be used to conduct InSight's research is a radio on the spacecraft that will send out signals that will be tracked on Earth. Following the signal produced by the radio sitting on the rotating planet will allow the research team to watch Mars rotate on its axis and actually watch that axis wobble a little bit. The size of that wobble will tells us about the distribution of material inside the planet and about the details of the core. What really drives the magnitude of these wobbles is the size of the core, its density, and whether it's solid or liquid."

The new lander will also be equipped with a weather station and camera that will provide further information about the Red Planet.

InSight's mission is expected to last for about one Mars–year or two Earth years. ##

A Habitable Environment on the Mars volcano Arsia, formed c. 200 million years ago, might still exist!

http://www.marsdaily.com/reports/A_habitable_environment_on_Martian_volcano_999.html

Editor: This is the most encouraging news about Mars as a future home for humans, we've yet heard!

May 28, 2014 – The slopes of a giant Martian volcano, once covered in glacial ice, may have been home to one of the most recent habitable environments yet found on the Red Planet, according to new research led by Brown University geologists.

Fire and Ice

Nearly twice as tall as Mount Everest, Arsia Mons is the third tallest volcano on Mars and one of the largest mountains in the solar system. This new analysis of the landforms surrounding Arsia Mons shows that eruptions along the volcano's northwest flank happened at the same time that a glacier covered the region around 210 million years ago.

The heat from those eruptions would have melted massive amounts of ice to form englacial lakes – bodies of water that form within glaciers like liquid bubbles in a half-frozen ice cube. The ice-covered lakes of Arsia Mons would have held hundreds of cubic kilometers of meltwater. And where there's water, there's the possibility of a habitable environment.

While 210 million years ago might not sound terribly recent, the Arsia Mons site is much younger than the habitable environments turned up by Curiosity and other Mars rovers, all likely older than 2.5 billion years. That Arsia Mons site is relatively young makes it an interesting target for possible future exploration. If signs of past life are ever found at those older sites, then Arsia Mons would be the next place to look, to see if life persisted that recently.

The northwest flank of Arsia Mons may once have been covered by glacial ice. That view got a big boost in 2003 when the geologists showed that terrain around Arsia Mons looks strikingly similar to landforms left by receding glaciers in the Dry Valleys of Antarctica. Parallel ridges toward the bottom of
the mountain appear to be “drop moraines” – piles of rubble deposited at the edges of a receding glacier. An assemblage of small hills in the area also appears to be debris left behind by slowly flowing glacial ice.

The glacier idea got another boost with recently developed climate models for Mars that take into account changes in the planet's axis tilt. The models suggested that during periods of increased tilt, ice now found at the poles would have migrated toward the equator.

That would make Mars’s giant mid-latitude mountains – Ascraeus Mons, Pavonis Mons and Arsia Mons – prime locations for glaciation around 210 million years ago.

Fire and ice

Using data from NASA's Mars Reconnaissance Orbiter, scientists looked for evidence that hot volcanic lava may have flowed in the region the same time that the glacier was present, and found plenty, including “pillow lava formations,” similar to those that form on Earth when lava erupts at the bottom of an ocean, as well as the kinds of ridges and mounds that form on Earth when a lava flow is constrained by glacial ice.

The pressure of the ice sheet constrains the lava flow, and glacial meltwater chills the erupting lava into fragments of volcanic glass, forming mounds and ridges with steep sides and flat tops. The analysis also turned up evidence of a river formed in a jokulhlaup, a massive flood that occurs when water trapped in a glacier breaks free.

Based on the sizes of the formations, scientists could estimate how much lava would have interacted with the glacier, and using basic thermodynamics, could then calculate how much meltwater that lava would produce. Two of the deposits would have created lakes containing around 40 cubic kilometers of water each, almost a third of the volume of Lake Tahoe in each lake. Another of the formations would have created around 20 cubic kilometers of water.

Even in the frigid conditions of Mars, that much ice-covered water would have remained liquid for a substantial period of time, hundreds or even a few thousand years. And that may have been long enough for the lakes to be colonized by microbial life forms, if in fact such creatures ever inhabited Mars.

"There's been a lot of work on Earth – though not as much as we would like – on the types of microbes that live in these englacial lakes. They've been studied mainly as an analog to Jupiter’s moon Europa, an entire planet that's an ice covered ocean. It seems possible that those same kinds of environments existed on Mars at this site in the relatively recent past.

There's also possibility, that some of that glacial ice may still be there. "Remnant craters and ridges strongly suggest that some of the glacial ice remains buried below rock and soil debris." That's interesting from a scientific point of view because it likely preserves in tiny bubbles a record of the atmosphere of Mars hundreds of millions of years ago.

An existing ice deposit might also be an exploitable water source for future human exploration.

**Editor:** Arsia Mons is just south of the equator, with Pavonis Mons, just astride the equator. That makes its western slope the most ideal launch-track anywhere in the Solar System. The Tharsis Ridge seems more and more the area in which a first wave of human settlement would have the greatest set of advantages, including very extensive mazes of pre-sheltered lavatubes.

---

**MARS Moons PHOBOS & DEIMOS**

**NASA Targets Moons of Mars for Potential Robotic Mission**


Above: Phobos left, Deimos right – to scale – and their orbits around Mars
NASA's current presence "ay" Mars ( Opportunity and Curiosity on the surface and Mars Odyssey and Mars Reconnaissance Orbiter above) may extend out to one of its two "asteroid-like" mini-moons a decade or so from now. At NASA's Ames Research Center in Moffett Field, Calif., a team is brainstorming a low-cost mission concept for a mission to Phobos or Deimos. Rather than start from scratch, they would use much of the hardware created for NASA's $280 million Lunar Atmosphere and Dust Environment Explorer (LADEE), that has been orbiting the "The") Moon since last September.

"We think we can do 'LADEE 2' for a few hundred million dollars and go to Phobos," says Ames director Pete Worden. LADEE “1” does not have a custom-crafted, mission-specific infrastructure but rather an Ames-developed "modular common spacecraft bus" that can be adapted for a variety of uses and destinations. This keeps costs down. AMES already has "some spare hardware hanging around" that the could use to lower the cost even further.

LADEE 2 could launch sometime after NASA's proposed “Asteroid Capture Mission.,” Worden added. The space agency is still mapping out the details of that mission — to attempt to drag a near-Earth space rock into a stable lunar orbit for future visitation by astronauts. (Current projections call for lofting the capture probe around 2019, with the asteroid arriving in lunar orbit in 2024 or 2025.)

While there is no money in the budget for a Phobos mission now, the plan to use off the shelf hardware and proven designs is a strong asset.

Most scientists have thought that Phobos and Deimos are former asteroids that were captured by Mars' gravity. [Editor; But a competing theory that they were both formed out of dust ring created by a major impact on Mars' surface has gained some support as what analysis we have is that the materials in the two moons are a good match for the ingredients in Mars’ crust.] A robotic mission to Phobos or Deimos could lead to an eventual manned visit. A human "base camp" on Phobos or Deimos is enticing to many researchers, who envision teleoperating rovers (via relay satellites) on the Martian surface and studying samples launched from the Red Planet up into orbit. (Phobos orbits a mere 6,000 km (3,700 mi) above Mars. Deimos circles at an average distance of 20,070 km (12,470 mi), just above the Mars- or "Areo"-stationary level.

A manned missions to Phobos or Deimos as a potential precursor, could get astronauts to the doorstep of Mars by the mid–2030s. — a goal laid out by President Barack Obama in 2010.

In addition to Opportunity and Curiosity n the surface and Mars Odyssey and the Mars Reconnaissance Orbiter in orbit another orbiter, called MAVEN, launched in November 2013 is scheduled to arrive in September 2014. NASA’s InSight orbiter and another Curiosity–like rover are scheduled to follow. ##

How Phobos Got Its Grooves


Billions of years ago, Mars suffered from numerous big impacts, and the resulting backwash ultimately scarred the surface of Phobos, the larger of Mars’ two tiny moons.

In 1976, images from NASA’s Viking orbiter revealed that the surface of Phobos is covered in numerous parallel, channel–like grooves. Over the years, researchers have come up with many hypotheses to explain the odd features, but the origin of the satellite’s grooves are still heavily debated today.
In the new study, a pair of researchers reviewed the evidence for the major hypotheses and concluded that only one holds water: **The grooves are chains of secondary impacts, the landing sites of material blasted to the Mars moon by impacts on the Red Planet.**

European Space Agency’s Mars Express Orbiter scientists mapped the grooves in much greater detail than ever before, and calculated that the amount of Mars material needed to form all of Phobos' grooves is about two orders of magnitude lower than the total ejecta from Mars' craters. They could even trace the ejecta that produced the grooves back to source areas on Mars.

**Mysterious origins**

Most scientists think Phobos and Deimos, Mars' two minuscule moons, are former asteroids captured by the Red Planet's gravity long ago. Phobos is 14 miles (22 kilometers) wide, while Deimos has a diameter of just 7.7 miles (12.4 km).

**Editor:** But some others believe that the two moons formed of debris blasted off Mars’ surface by an impacting planetoid, as the chemical makeup of Mars and its two moonlets are quite similar.

The 3-billion-year-old grooves on Phobos can be divided into different "families," with each groove plane running parallel to the other grooves within the same family, Murray told Space.com.

The widths of the grooves vary greatly, from 23 m (76 ft) to 475 m (1,558 ft). Similarly, they come in a large range of lengths — at least one groove stretches for 30 km (19 mi) without any breaks, while others are only a little more than 1.6 km (1 mi) long. The channels cover almost the entire surface of the moon, except for a relatively small area on the hemisphere facing away from Mars. (Just as the Moon always has the same face turned towards Earth), Phobos is tidally locked with Mars, with one side of the moon facing the planet at all times.

Some scientists have previously speculated that the grooves are fractures resulting from tidal forces, the impact that created Phobos' prominent Stickney Crater or other sources. There are several issues with all fracture hypotheses for the origin of the grooves: the near–perfect alignment of the grooves within each family doesn't fit with other fracture fields throughout the solar system.

None of the other hypotheses can explain all the features of the grooves. ##

---

**2745 Photo Images of Mars**


**HUMANS TO MARS: HANDLING THE RISKS**

**Editor:** It is NASA, not serious Human Mars Missions supporters, who have been dismissive about risks involved. SEE THE FIRST ARTICLE IN THE ARTICLES & ESSAYS section below.

**Health risks of Mars mission (without shielding) would exceed NASA limits**


EDITOR'S NOTE: This article assumes humans would be sent to Mars in ships that were not adequately shielded, and stayed on Mars in habitats not properly shielded. No one proposes that, except NASA (and Mars One.)

We need to develop **adequate shielding**, for example the thick walls of a Bigelow inflatable Crew Compartment with a water bag inner wall lining

But we also need to provide **artificial gravity** en route, especially "to" Mars, lest the astronauts arrive too weak to “hit the ground running” and waste extremely expensive time doing nothing but getting bedrest.

While the authors assumptions about the dangers of radiation are correct, their assertion that we need to think twice about sending humans to Mars, based on an apparent assumption that we cannot adequately protect them, is not worth printing. For shame!

But read the article for yourself and the Articles in the Articles & Essays section below. ##
NASA Mulls Ethics of Sending Astronauts on Long Space Voyages


According to a panel of health and ethics experts, NASA should set up a clear set of ethical rules regarding the health of astronauts on long-duration spaceflights — such as a near future trip to Mars,

**As the spaceships that would carry manned missions to Mars are now envisioned**, astronauts on a round trip to Mars would experience a level of radiation exposure that violate at least one of NASA's existing health limits. Such a trip to Mars in inadequately shielded ships now designed would expose astronauts to enough radiation to increase their lifetime risk of developing fatal cancer by more than 3 percent, a health limitation imposed by NASA. **[A risk many would-be Mars explorers would be willing to accept, were it left up to them.]**

While NASA should not relax its current health standards for long-duration space travel, the agency should consider developing ethics guidelines on when exceptions to those standards should be made for deep-space voyages, a report from the National Academy of Science's Institute of Medicine committee released on April 2. **[Unfortunately, the panel did not consider spaceship design standards that would evaporate the problem.]**

Some of the risks astronauts face during long duration flights include vision impairment, heightened cancer risk due to radiation exposure and bone loss from the microgravity environment.

The first step in this ethical framework should be deciding if a long-term space mission's value is worth the potential risk to the astronauts performing it. If a mission is considered "ethically acceptable," then NASA officials should develop a system for granting the exception. The IOM report does not comment on the value of specific missions.

According to results from NASA's Mars rover Curiosity, a 180-day flight to the Red Planet followed by a 600-day stay on Mars and a 180-day flight back to Earth would expose astronauts to about 1.01 sieverts (radiation units). Some researchers consider that level of radiation manageable, however, it would violate NASA's current standard that caps the excess cancer risk for a given astronaut at 3 percent.

**Editor:** the committee did not consider that the 600 day stay on Mars need not be included if the explorers simply shielded their living quarters with Martian regolith - sandy soil. And providing shielding on the spacecraft bringing them there and returning them, need also not be a prohibitive expense.

The committee proposed that these ethical principles should help guide mission decisions:

- Avoid harm by preventing harm, exercising caution, and removing or mitigating harms that occur
- Provide benefits to society
- Seek a favorable and acceptable balance of risk of harm and potential for benefit
- Respect autonomy by allowing individual astronauts to make voluntary decisions regarding participation in proposed missions
- Ensure fair processes and provide equality of opportunity for mission participation and crew selection
- Recognize fidelity and the individual sacrifices made for the benefit of society, as well as honor societal obligations in return, by offering health care and protection for astronauts during missions and over the course of their lifetimes.

NASA funded the IOM report: "Health Standards for Long-Duration and Exploration Spaceflight: Ethics Principles, Responsibilities and Decision Framework."

---

Possible Mars Mission 'Showstopper': Vision Risks for Astronauts


Mars may possess a stark and austere beauty, but a manned Red Planet mission will likely not be easy on the eyes.

Recently, scientists have begun realizing that spaceflight can cause serious and perhaps permanent vision problems for astronauts [in prolonged microgravity]. NASA researchers are working hard to understand the issue, which could present a major hurdle to mounting manned missions to Mars and other faraway destinations [if we do not provide artificial gravity enroute and returning.

**Editor's Comment:** Mars enthusiasts decades ago published sketches of Mars-bound craft with artificial gravity.

Hollywood had the idea also! Consider the circular jogging track in Jupiter-bound ship.

No human has been on the Moon long enough to determine whether the "sixthweight" of the Moon is enough to avoid some, most, or all of the visual problems encountered on the Space Station. To call the problem a "potential showstopper" indicates unwillingness to consider alternatives, let alone mention them.
From Stanley Kubrick’s 2001: A Space Odyssey (1968)

The authors go on to note that the human body suffers in the microgravity environment of space. For example, without effective countermeasures — i.e., vigorous weight-bearing exercise — astronauts’ muscles atrophy and their bones shed calcium, becoming more and more brittle over time. That is clear, but “that there is no alternative” is an absurd conclusion.

NASA has always shied away from experiments with artificial gravity, which we agree can be tricky. You don’t want the two weighted end compartments twisting and counter-twisting at the ends of boom that was not stiff. Docking at a hub can also be tricky. The idea is to experiment until you get it right, not to shy away from the problem.

The overriding consideration is to get people to Mars “in shape” to “hit the ground running!”

Red Planet Roadmap: DC Conference Eyes Manned Mars Missions


April 22, 2014 – Sending astronauts to the surface of Mars has been a longtime goal for NASA and other space exploration agencies. That Martian goal takes center stage in a Washington, D.C. conference, and you could watch it live online. Nearly 500 scientists gathered in Washington for “Humans 2 Mars Summit 2014”, a 3-day conference April 22–23 aiming to explore how to send humans to the Red Planet.

Private Mars One Colony Project: 705 Astronaut Candidates Pass Latest Cut

http://www.space.com/20764-how-to-die-on-mars-the-mars-one-project-explained-video.html

May 5 – The Netherlands–based nonprofit Mars One, which aims to establish a Red Planet settlement beginning in 2025, announced that it had sliced its pool of potential colonists from 1,058 down to 705. The remaining astronaut candidates now advance to an interview round with a selection committee, to better understand our candidates. “They must show knowledge, intelligence, adaptability and personality.”

Editor: So far this company has shown no indication that it has picked a site on Mars, or that it has any idea of what kind of site would best favor success (e.g. access to water). The illustrations seem to show ignorance about Mars’ climate (very similar to that of Antarctica’s Dry Valleys) or radiation hazards (illustrations show no plan to properly shield either living and/or working areas.) Unless they begin paying attention to these things the project is doomed to a tragic end. If volunteers are sent to Mars without a sound plan to make the effort permanent, then we are looking at “Mars Tourism” on a high-risk venture. PK
NASA, MakerBot Launch Contest for 3D-Printed Mars Base


When the first human settlers land on Mars, they'll be spending a lot of time indoors, and now you can design what that Martian base might be like with a new 3D printing contest. MakerBot in Brooklyn, New York and NASA’s Jet Propulsion Laboratory have teamed up to launch the MakerBot Mars Base Challenge, selling innovative ideas for a habitat that could support a crew of astronauts on Mars’ surface.

Mars is hostile to life as we know it. It is frigid, prone to dust storms and bombarded with dangerous cosmic rays. To survive, future astronauts will need a sturdy, utilitarian home — perhaps made out of parts from a 3D printer, for on-the-spot construction. That's where the MakerBot Mars Base Challenge comes in. A panel of experts from MakerBot and the Jet Propulsion Laboratory in Pasadena, California, will judge designs on their scientific feasibility, creativity and printability. Winners will be awarded MakerBot products, with the 1st-prize winner receiving a Replicator 2 Desktop 3D Printer.

A 3D printing Mars challenge

The MakerBot Mars Base Challenge will be open through June 12. Winners will be awarded MakerBot products, with the 1st-prize winner receiving a Replicator 2 Desktop 3D Printer. As of June 5, there were 66 proposals submitted, many of them using some combination of dome-covered modules.

"Taking into consideration, Mars’ extreme cold, high radiation levels, lack of oxygen, and frequent dust storms into consideration, design a utilitarian Mars base that can withstand the elements and maybe even make you feel at home, despite being 140 million miles away from Earth, on average."

The designs will be rated for scientific feasibility, creativity and printability.

Officials with the Mars Foundation are looking into how the technique could be used to 3D-print sustainable Martian houses out of raw material on the planet.

NASA even plans to launch the first 3D printer in space later this year. That printer, called the 3D Printing in Zero G Experiment, was built by the company Made in Space to test the feasibility for 3D printing spare parts or tools on the International Space Station.

To learn more about the MakerBot Mars Base Challenge, visit: [http://www.thingiverse.com/challenges/Mars](http://www.thingiverse.com/challenges/Mars)


Early Mars Cuisine? How about Grasshoppers with a side of Fungi (Op-Ed)

http://www.space.com/25374-mars-grasshopper-cuisine.html

April 4, 2014 – The first humans to land and explore Mars will certainly have to bring their food with them. But if a permanent settlement on Mars is to be both physically and economically sustainable, settlers will have to grow most, if not all of their food on location.

Food is a consumable, which means that the settlers will need a continuous supply. Shipping anything to Mars will be monumentally expensive, at least in the early years. Sending basic food to Mars would likely cost $7,000 to $10,000 per kilogram just to ship out of Earth's orbit.

Because of orbital mechanics, there will be gaps of roughly 26 months between supply ship arrivals, which means that settlers will need to have to a two-plus years food supply to last until the next new shipment arrives – and double that for insurance against a shipment mishap! Furthermore, it is not possible to ship fresh vegetables and fruits that far — or to store them for many months. Few foods remain viable over such durations without losing quality.
NASA has been funding research into methods of storing food for long periods. This work will no doubt be useful. But there has been only limited research into actually growing food under the conditions that we will find on Mars where gravity is 38% that on Earth, [will plants to grow taller on Mars? and there may also be reduced–pressure in the Mars habitats (for cost and reduction of stress on hulls as well as on spacesuits)]. In the near term, before colonists can construct greenhouses, they will have to use artificial light — from LEDs, for example — to power their plants' photosynthesis.

NASA has conducted plant-growth research in microgravity on the International Space Station and in the Long Duration Exposure Facility [above], a 9,700 kg (21,400-lbs) cylindrical satellite that orbited Earth for nearly six years in the 1980s. Still, the effects that these factors will have on plant growth, specifically in a Mars environment, are still largely in the theoretical stages of research. Only actual plant-research experiments that simulate Mars' gravity and pressure can answer those questions. A manned laboratory in low–Earth orbit could simulate Mars’ (or the Moon's) low–gravity. Placing it near the Space Station would be one logical and logistically convenient way of doing this.

The needed technology exists today. To provide Mars-level (38% Earth normal) gravity, the structure would consist of a tether a couple hundred meters (around 650 ft) in length, with the lab on one end and a spent, final–stage booster rocket at the other. The lab would have to remain close enough so the crew could escape in the event of a failure, or dock with the ISS to replenish food. Powered by two solar panels pointed toward the sun, the lab would rotate at two revolutions per minute (rpm), simulating Mars’s gravity. (Two rpm is the maximum rotation rate crew members could tolerate without running the danger of dizziness and disorientation).

The lab could be cylindrical and divided into several sections, like the layers of a cake. One section could house the crew, and another the plants in experimental growing media, such as simulated Mars soil or fluid for hydroponic gardening. A third section could contain the physical equipment necessary to keep the lab supplied with power, the air filtered, the water recycled, the rotation stable and so on. The lab section would replicate the atmospheric pressure suggested for future Mars habitats by Robert Zubrin, President of The Mars Society. Due to the reduced air pressure, the crew's section might need to have elevated oxygen levels, while the plant section would require elevated carbon dioxide levels to foster plant growth. (Special precautions would minimize the danger of fire in the high–oxygen environment.)

When working in the plant section, crew members would need to wear oxygen masks, similar to those worn by high–altitude fliers. Under conditions similar to those expected on Mars, plant studies could determine which species would thrive and which would not. For this to become a viable possibility, NASA engineers would have to solve some daunting technological materials–science and physics issues. But if it turns out that this type of lab is not possible, other alternatives exist.

Unmanned spacecraft can carry experiments and float freely in Earth's orbit, as the Long Duration Exposure Facility did. Technology already exists for enclosed units containing plants with automated plant–watering systems. LED lights have an average lifetime of 15,000 to 25,000 hours, amounting to nearly 10 years with seven hours of daily light exposure for plants.

Simulating Gravity

Engineers could configure this system to emulate Mars’ gravity. Indeed, the Mars Gravity Biosatellite competition (created by the Mars Society following a brainstorm session between Zubrin and Elon Musk, founder of SpaceX) provides a model for how to do this. That project, which focused on studying mammals in Mars gravity, could possibly be adapted for the study of plants.

Food sources for Mars settlers

A vegetarian diet is logical, as well as the simplest in terms of agricultural management. Soybeans provide basic proteins capable of sustaining human health. Greens, sprouts and even seaweed may help...
create a balanced diet. Indeed, astronauts have successfully grown peas and mizuna lettuce in space, along with carbohydrate staples like wheat and rice. All would be likely choices as mainstay foods.

Direct sunlight on Mars will be less than half Earth levels. In the early years, the “Martians” will not have access to fruits containing vitamin C, except in vitamins.

All of the above-mentioned crops can grow hydroponically to conserve space and resources. Some experiments growing plants in simulated Martian soil have also met with success. In addition to providing a food source, greens offer the added benefits of converting carbon dioxide exhaled by settlers into oxygen, essential for maintaining a long-term, bio-regenerative life support system. Plants also provide the psychological benefits of relaxation and a general sense of well-being.

Fungi, specifically mushrooms, are excellent, low-maintenance food sources that require little or no light. Mushrooms provide essential nutrients, including vitamin D and vitamin B-6. Easy to grow and harvest, mushrooms are ingredients in many popular dishes are ingredients in many popular dishes. The fungi could grow in compost created using waste material from other agricultural processes, as well as sanitary waste. This use of waste material would be part of a self-sustaining system.

Mars settlers could also turn to grasshoppers as an additional food resource. Grasshoppers are a major source of animal protein in Asia, Africa and South America. Grasshoppers are twice as efficient as are pigs, and five times as efficient as cattle in converting vegetable mass into protein.

[On a dare, the editor, then 18, found fried grasshoppers quite tasty, and crunchy like potato chips.]

The husbandry associated with raising grasshoppers is relatively simple, and their rapid reproduction rate and short life cycle allows a stable and continuous harvest. The insects could become part of the Mars culture, too. Mars settlers on the Red Planet would likely come from all over the world, and those used to eating insects will have the advantage.

"Food replicators?" We have successfully synthesized meat, using a 3D printer to align stem cells from animals in laboratory Petri dishes, simulated hamburger, chicken, even fish from materials never part of living creatures could put meat-eaters and Vegetarians, even “Vegans” on the same level.

NASA has also experimented with using 3D printers for making chocolate and even pizza.


The grasshoppers would make a better dessert if dipped in the 3D-printed chocolate. [Editor, from experience, suggests cheese dip.] Perhaps in the future, the list of 3D-printed proteins will include fish.

It won’t take Mars settlers too long to develop their own unique cuisine.

NASA May Put Greenhouse on Mars in 2021


Researchers have proposed putting a plant–growth experiment on NASA’s next Mars rover, which is scheduled to launch in mid-2020 and land on the Red Planet in early 2021. The Mars Plant Experiment (MPX) project could help lay the foundation for the colonization of Mars.
To design a sustainable base on Mars, we need to establish that plants can grow on Mars. The 2020 Mars rover could play gardener, digging a hole with its robotic arm and planting seeds in the Red Planet's dirt. But MPX would be entirely self-contained – grown hydroponically – eliminating the chance that Earth life could escape and perhaps get a foothold in Mars soil which might be too acidic or alkaline.

The experiment would employ a clear "CubeSat" box – 10 cm (4") on a side — affixed to the exterior of the 2020 rover. It would hold Earth air and about 200 seeds of Arabidopsis, a small flowering plant that's commonly used in scientific research. The seeds would receive water when the rover touched down on Mars, and would then be allowed to grow for two weeks or so – the first “greenhouse on Mars.”

MPX would provide an organism-level test of the Mars environment, showing how Earth life deals with the Mars' relatively high radiation levels and 38% Earth-level gravity. From this simple experiment we should be able to design greenhouses for a sustainable Mars base. This would be a landmark moment for human expansion in space – the first multicellular organism to grow, live and die on another planet.

---

**Mars Orbiter spots fresh just made new crater**

New imagery from NASA's Mars Reconnaissance Orbiter has revealed the 49 meter (160-foot)-wide crater, which scientists have determined was created between March 27–28, 2012. The imagery also reveals possible landslides that occurred as a result of the impact.

Do watch the Video: Conclusions from this event show how often small objects hit ALL the planets though on planets with thick atmospheres, like Earth, most of these do not hit the surface.

---

**Curiosity looks up and captures Phobos eclipsing Deimos**

This movie clip shows Phobos, the larger of the two moons of Mars, passing in front of the other Martian moon, Deimos, on August 1 2013, from the perspective of NASA’s Mars rover Curiosity.

The clip includes interpolated frames smoothing out the motion between frames from Curiosity's Mast Camera (Mastcam). Mastcam took images 1.4 seconds apart. With the interpolated frames, this clip has 10 frames per second. It runs for 20 seconds, matching the actual time elapsed.

---

Above: Graphic illustrating the Mars Plant Experiment (MPX) concept, which aims to send a tiny greenhouse to the Red Planet along with NASA's next Mars rover in 2021. ##

http://www.space.com/images/i/000/039/074/original/mpx-mars-concept.jpg?1399325285

---

Above: a series of stills extracted from the Video as the event proceeds left to right
NASA Funds 12 Futuristic Space Tech Concepts: 2 Mars–related

http://www.nasa.gov/content/niac-2014-phase-i-selections/

- Mars Ecopoiesis Test Bed (Eugene Boland, Techshot, Inc.) Proposed for development in a 3–phase program concluding with a device for studying the sur–vival of terrestrial life forms on the surface of Mars prior to abiological planetary engineering. www.nasa.gov/content/mars-ecopoiesis-test-bed/

> Ecopoiesis is the concept of initiating life in a new place; more precisely, the creation of an ecosystem capable of supporting life, initiating “terraforming” using physical, chemical and biological means including the introduction of ecosystem–building pioneer organisms.

> The proposed concept will be subjected to extensive laboratory testing directed toward the ultimate emplacement of a test bed on Mars to test and demonstrate the activity of pioneer organisms selected on the basis of research on Earth.

> To achieve this a device is proposed to penetrate and surround a sample of Martian regolith at a carefully selected site likely to experience transients of liquid water, completely seal itself to avoid planetary contamination, release carefully selected Earth organisms (extremophiles like cyanobacteria), sense the presence or absence of a metabolic product (like O2), and report to a Mars–orbiting relay satellite: the first major leap from laboratory studies to implementation of experimental (vs. analytical) planetary in–situ research of greatest interest to planetary biology, ecopoiesis and terraforming.

- PERISCOPE: PERIapsis Subsurface Cave OPtical Explorer (Jeffrey Nosanov, JPL) http://www.nasa.gov/content/periscope-periapsis–subsurface-cave–optical–explorer/

Description– [Editor: proposed for the Moon, this concept should be valid for Mars as well.]

Lunar sub–surface exploration has been a topic of discussion since the Lunar Reconnaissance Orbiter identified openings (cave skylights) on the surface of the moon in 2009. NASA’s participation in the UK’s MoonLITE mission shows the wide appeal of this phenomenon. NASA has focused internally on two distinct architectures to explore the lunar sub–surface: robotic (rover based) or human (astronaut based). Both are unfortunately beyond the limits of NASA’s conceivable near– and mid–term resource allocation. We present a third option: mapping and characterization of lunar subsurface structures with an orbiting platform performing photon time–of–flight imaging. A tabletop demonstration of the imaging technique, “seeing around corners” was led by one of the authors and we assert that this concept can be extended to a lunar orbiting platform architecture.
June 16, 2014 - A private mission could return Martian samples to Earth by 2020 without even touching down on the Red Planet. The BoldlyGo Institute, a Colorado–based nonprofit, is working to develop the Sample Collection to Investigate Mars (SCIM) mission, which would send a spacecraft skimming through Mars’ atmosphere to gather dust and return, home without the difficulty of landing. SCIM could launch as soon as 2018, possibly returning samples to Earth in July 2020.

Left: SCIM – Sample Collection to Investigate Mars – will return the first samples of Martian materials to Earth without the complexity and risk of landing, at a fraction of the cost. Credit: BoldlyGo.org

Right: The SCIM particle capture device relies on cells filled with aerogel.

A dusty ‘catcher’s mitt’

Scheduled to interact with Mars during its dustiest season of, SCIM would dip down to between 35 and 40 km (22–25 mi) inside Mars’ atmosphere. It would carry cells filled with aerogel that would act “as a catcher’s mitt,” as it hurtled through the Martian sky. The gel would scoop up thousands of tiny particles, heat-sterilizing them before bringing them inside the capsule, where they would travel safely to Earth.

Several different designs for the "catcher’s mitt" are still under consideration.

The sterilization process would ensure the material could be safely returned to Earth without contamination concerns, while still preserving scientific objectives, and following the guidelines for international planetary protection protocols established by the Committee on Space Research.

Why sample dusty atmosphere? Dust storms on the Red Planet stir up material affected by weathering, precipitation and volcanism. This dust is an ideal sample of the Martian surface, “a microscopic average rock collection from Mars.”

Back on Earth, scientists could process these Martian materials to an extent that just can't be accomplished on Mars, allowing many researchers around the world to perform a variety of tests. Indeed, most scientists regard sample-return as the best way to look for signs of life on Mars.

Because the SCIM craft wouldn't have to land, its bullet-shaped body wouldn't need to slow down, because it would pass through the atmosphere without stopping, emerging on the far side of the planet. It would engage in a slight orbital correction maneuver, using its 22-Newton thruster, and return to Earth.

However, SCIM wouldn't take the place of a full-scale Mars sample return mission. But it could be done in less time, for less cost, at less risk – and represent a planet-wide sample, not just one small area.
Lean and mean

The basic concept was used by NASA’s Stardust mission, which captured samples from the heart of the comet Wild 2 and returned them to Earth in 2006. SCIM's aerogel comes from the Stardust concept, and the sample-return capsule is modeled on the comet-chasing craft as well.

In 2002, SCIM was one of the four finalists for NASA's Mars Scout program, which ultimately selected the Phoenix lander. As a result, the mission is well developed, having spent over a decade being refined, and having passed NASA's stringent qualifications.

At the same time, the mission will avoid some of the problems that raise governmental costs. Part of the streamlining procedure involves building smarter. For example, systems that have already been well developed can have their testing scaled down, allowing greater focus on the areas at higher risk.

Private industry science

BoldlyGo was created to delve into scientific frontiers that the government just can’t reach. The company looks for outstanding ideas for missions that won't fly because of limited resources.

Do watch the Video! (2nd URL above)

New Ion-Propulsion System Could Deliver Time Capsule to Mars


WASHINGTON — A student-led mission aims to send a time capsule to Mars. Three tiny "cubesats" containing photos, videos and other media provided by people around the world to Mars, using "ion-electrospray technology," which could deliver the cubesats to Mars in four months.

Cubesat skimming over Mars through upper atmosphere

Traditional thrusters burn chemicals to produce thrust. By contrast, ion–propulsion systems use electrical energy to accelerate particles, which is much more efficient.

Each cubesat will be 10 cm (3.9 in) on a side, so they need a small rocket that consumes very little propellant. Ion engines are too bulky and expensive for this mission. A new way to miniaturize these engines involves a strong electric field to a liquid–salt propellant. Using this ion–electrospray technology, only a small amount of propellant would be needed to get the miniature spacecraft to Mars from Earth orbit. Each of the mission's three cubesats will contain 40 thruster pairs, made using micromachining techniques.

The team is under contract with NASA and the Department of Defense to develop the new ion–propulsion system. "We're on the second generation," he said, "and we plan to fly them early next year for the first time." Time Capsule to Mars leaders hope to launch the mission in the next five years, if they're able to raise enough money.

If the propulsion system is successful, it could be used on other spacecraft — possibly even manned spacecraft. However, for this the engines would need to be very well tested. ##
Fly Me to the Minimoon: Tiny Asteroids Near Earth Touted for Human Exploration


April 2, 2014 – NASA is drawing up plans to capture a near-Earth asteroid and drag it back to a stable lunar orbit, where astronauts could visit it in the future. A manned mission to an asteroid may be quite a bit less complicated than NASA had thought. Such space rocks already cruise near our planet and would make interesting targets for manned exploration.

Researchers detailed the idea of dispatching a crew of astronauts to rendezvous with these easily reachable and scientifically interesting asteroids here March 15 at Microsymposium 55, titled "Scientific Destinations for Human Exploration." The discussion was co-sponsored by Brown University, Russia's Vernadsky Institute, Brown-MIT and the NASA Solar System Exploration Research Virtual Institute (SSERVI).

This illustration depicts a trajectory for a mission to visit a minimoon, a tiny asteroid in the Earth–moon space that may be great targets for astronaut visits.

Full size image: http://www.space.com/images/i/000/038/169/original/minimoons-asteroid-trajectory.jpg

Scientists think that “minimoons” have a lot of promise. Researchers recently discovered that some near-Earth asteroids or NEAs are temporarily captured in Earth–moon space. Each several meters across, make at least one orbit around Earth, some many loops, as some of them very naturally find their way into the Lagrange points, gravitationally stable spots in space. Some minimoons may be in a "sweet spot," with long dynamical lifetimes inside the moon's orbit.

Low mission risk

Minimoons come in various dimensions, from the size of a washing machine to objects as big as a dump truck. As such they offer new prospective targets for human exploration. NASA can learn from these small chunks what they need to know about asteroids at a much lower cost and risk as well as for far less expense and risk.
Minimoon mystery

NASA now needs a detailed observational and theoretical study to understand the minimoon population. Some tantalizing hints have suggested that minimoons have already been spotted by the U.S. Department of Defense Space Surveillance Network. In 1994, that network detected objects on geocentric orbits. Their orbits matched "no known human activity" but did line up with hypothesized minimoon orbits.

The DoD using radar and optical tools to detect spy satellites from other countries, But can the military find — or has it already found — minimoons? If so, can the DoD release its data?

Civilian amateur astronomers

Amateurs could tap the Subaru 8.2-meter optical-infrared telescope at the summit of Mauna Kea on the island of Hawaii to look for minimoons.

Intriguing science

Those interested in minimoons see no problem in sending astronauts aboard NASA’s Orion spacecraft to investigate these little objects. Orion crew members could even haul samples or the entire miniature asteroid back to Earth. Flights to these nearby objects would only take weeks,

Minimoons are probably about the size of the fundamental building blocks from early solar system formation, but some could be debris from the collision of larger asteroids, Considering how much we might learn from observing a representative number of these little bodies, they warrant an in depth study.


Red Tape Hinders Study of Asteroid Impacts on Earth

Asteroid impacts are 3 to 10 times more common than previously thought

http://www.space.com/13129-killer-asteroids-wise.html

April 20, 2014 - Government red tape is making it tougher for researchers to study and characterize asteroid strikes on Earth, which are apparently more common than previously thought. There is a bureaucratic snafu that affects the use of U.S. government space assets that help scientists study “airbursts” like the meteor that exploded without warning over Chelyabinsk, Russia last year.

At issue is the ability to combine space data with outputs from a global network of seismic, infrasound and hydroacoustic sensors that have been deployed worldwide to provide treaty verification for a nuclear test ban. This network is the International Monitoring System (IMS) overseen by the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO).

In recent years, the IMS has detected shock waves from many airbursts, providing further evidence that asteroid impacts are much more frequent that asteroid impacts are much more frequent than previously thought. Ideally, matching observations from spacecraft with measurements from CTBTOs infrasound detectors would give scientists more of a heads-up on what's raining down on Earth.

Memorandum of agreement

On January 18, 2013, the United States Air Force Space Command signed a memorandum of agreement with NASA’s Science Mission Directorate. It listed specifics for the public release of meteor data from sources such as high-flying, secretive U.S. government space sensors. With that agreement in place, NASA’s Near Earth Object (NEO) Observation Program started receiving information on fireball events based on analysis of data collected by U.S. government sensors. Details of atmospheric meteor explosions recorded by U.S. military spacecraft sensors, were posted on a publicly accessible NASA website run by the Jet Propulsion Laboratory (JPL) in Pasadena, Calif.

This military–civil cooperation was spurred by the details of the February 2013 fireball explosion over Chelyabinsk, Russia — termed a "super bolide" event. The website postings are designed to assist the scientific community’s investigation of bolides, or exceptionally bright fireballs.

However, many scientists noted that the JPL website had not been updated recently. Presumably there was some sort of delay, as some fairly big events were detected by infrasound in the last year.

Editor: confer the unabridged article linked above for the “Excuses” in not sharing information.

Renaissance in global detection

Since its mid–1990s inception, data from the International Monitoring System of the CTBTO has led to a renaissance in global detection of low–frequency airwaves (infrasound) from bolides. Infrasonic bolide detection lets us monitor all parts of the globe, particularly the oceans, for airbursts and provide an
estimate of their location and origin time. With some additional signal processing and comparison with
other explosive events in the atmosphere having known source energies, CTBTO infrasound airburst
energies are now routinely computed and have been found to be robust over many orders of magnitude.

The MS network currently has more than over 40 infrasound stations, making global monitoring for
events as small as 1 kiloton relatively complete. As the network continues to expand and new, automated
processing techniques are applied to IMS infrasound data, we expect more airburst events to be identified
even sooner after they occur. ##

Asteroid impacts are more common than thought

According to former astronaut Ed Lu, CEO of the B612 Foundation, asteroid impacts are actually 3
to 10 times more common than previously thought. "The fact that none of these asteroid impacts shown in
the video was detected in advance is proof that "the only thing preventing a catastrophe from a city–
killer–sized asteroid is blind luck," Lu said in a statement.

We have been lucky

Since the start of the 21st century, dozens of incoming asteroids have slammed into Earth, some of
them packing far more energy than a city-destroying atomic bomb, a new animation illustrates. Many of
these asteroid collisions go unnoticed because they explode too high up in the atmosphere to cause
damage on the ground. What's more, these impacts often occur above remote parts of the ocean. But as
the new animation shows, sometimes a powerful collision occurs over an area heavily populated by
humans. A throbbing red dot over Chelyabinsk, Russia, marks the spot where a 600-kiloton meteor impact
occurred in February 2013, damaging hundreds of buildings and injuring more than 1,000 people.

Most asteroids large enough to destroy an entire country or continent have been detected. However
"Less than 10,000 of the more than a million dangerous asteroids with the potential to destroy an
entire major metropolitan area have been found by all existing space or terrestrially operated
observatories," says former NASA astronaut Ed Lu, who started the B612 Foundation in 2002 with fellow
astronaut Rusty Schweickart and colleagues. The B612 Foundation is trying to build a privately funded
infrared space telescope to find dangerous asteroids while they are still millions of miles away.

"Because we don't know where or when the next major impact will occur, the only thing
preventing a catastrophe from a 'city-killer' sized asteroid has been blind luck."
http://www.space.com/20636-private-asteroid-space-telescope-b612.html

This Sentinel Space Telescope mission could ideally give us years to devise a plan to deflect killer
space rocks. The organization is aiming for a 2018 launch.

Asteroid Impacts on Earth More Powerful than Nuclear Bomb | Videos

Asteroid Zoo Asks Public to Find Dangerous Space Rocks
http://www.space.com/26349-asteroid-zoo-zooniverse-planetary-resources.html

June 24, 2014 – Now you can join the hunt for potentially hazardous — or incredibly valuable — asteroids.
The asteroid-mining firm Planetary Resources and citizen-science site Zooniverse have teamed up to
launch Asteroid Zoo, a Web–based project that asks people around the world to scour image
archives for undiscovered space rocks that zoom close to Earth.
The project aims to help find asteroids that may pose a risk to the planet down the road, as well as space rocks that may be good mining targets. "With Asteroid Zoo, we hope to extend the effort to discover asteroids beyond astronomers and harness the wisdom of crowds to provide a real benefit to Earth."

Asteroid Zoo users will search through photos taken by the Catalina Sky Survey, an Arizona–based observing effort that has discovered nearly half of the roughly 11,000 near-Earth asteroids identified to date. The project turns the asteroid hunt into a game that users can play on their computers or mobile devices. The results could have long-term scientific benefits, helping to streamline and automate the search. Asteroid Zoo hope to use the classifications provided by volunteers to improve automated searching and suggest new methods by which machines might take up the strain.

Scientists believe millions of asteroids cruise through space in Earth's neighborhood, the vast majority of which have yet to be found and tracked. Less than 1% of near-Earth asteroids that are at least 100 feet (30 meters) wide — which could cause major damage if they hit — have been identified to date. To learn more about Asteroid Zoo, visit http://www.asteroidzoo.org.

NASA and Slooh Community Telescope Seek Citizen Asteroid Hunters


NASA is enlisting amateur astronomers to hunt for killer space rocks in Earth's neighborhood, signing a deal with the online Slooh community telescope to get citizen scientists involved in tracking near-Earth asteroids.

"We are excited by the opportunity to tap into Slooh's network of amateur astronomers, who are already producing scientific papers with their work," Jason Kessler, program executive for the Asteroid Grand Challenge, said in a statement. "We look forward to expanding the meaningful science the Slooh network (www.slooh.com) can provide in support of the Grand Challenge to find potentially deadly space rocks before they pose a threat to Earth.

So far, scientists have catalogued more than 90% of the mountain-sized near-Earth asteroids, or objects wider than 1 km (0.6 mi), according to NASA's estimates. Space rocks of this size could cause destruction on a global scale if they were to collide with Earth.

Smaller space rocks are more elusive. Only about 30% of the estimated 15,000 near-Earth asteroids around 140 m (460 ft) wide have been found. There may be more than 1 million near-Earth objects with a diameter of about 30 m (100 ft); less than 1 percent of those have been detected, NASA estimates.

NASA's Asteroid-Capture Mission May Test New Method to Defend Earth


Plan to park asteroid near the Moon to also test a new way to protect Earth from dangerous space rocks.

In this concept image, the robotic vehicle descends to the surface of a large asteroid to collect a boulder that it can redirect to a distant retrograde lunar orbit. Full size image: www.space.com/images/i/000/038/090/original/asteroid-initiative-4.jpg?1396025168

Last year, NASA announced that it intends to tow a near-Earth asteroid into a stable lunar orbit, and for astronauts visit it repeatedly for research and exploration. NASA is still working out the details of the mission, which may bag up an entire small space rock or snag a boulder off the surface of a larger asteroid. In the boulder option, the asteroid-capture mission will also include a planetary-defense demonstration, providing the first in–space test of a so-called "enhanced gravity tractor." officials said.
Given enough lead time, asteroids on a collision course with Earth could be safely deflected using a handful of methods, such as the "gravity tractor" technique, in which a robotic probe flies alongside a space rock for months or years, gradually nudging it off course via a slight gravitational tug.

In addition to the gravity tractor method, incoming space rocks could also be knocked off course with a direct hit by a "kinetic impactor." (These techniques could also be combined in two coordinated space missions, slamming an asteroid with an impactor probe and then sending a gravity tractor out to finish the job.) More extreme measures might be necessary for very large asteroids and rocks detected with little warning time. In such cases, a nuclear bomb might be humanity's best — and only — option.

The greater the shepherding probe’s mass, the stronger its gravitational pull is. And poaching a boulder off a potentially hazardous asteroid would allow a deflection mission to increase its mass significantly without having to pay any additional launch costs to haul that much added mass from Earth.

About a dozen promising candidates for the asteroid-capture mission have been identified — six or so for each of the two options. The best target for the boulder-grab mission may be Itokawa, a 1,750-foot-long (530 meters) space rock visited by Japan’s Hayabusa probe in 2005. NASA wants astronauts to visit the redirected asteroid by 2025, to meet an exploration deadline set by President Barack Obama.

The asteroid-capture mission remains in a "preformulation" phase, as NASA is still gathering data and ideas. The agency hopes to have a basic mission concept in place by around the end of 2014.

---

**Asteroid that whizzed by Earth may be grabbed by NASA**


Jun 19th 2014 – WASHINGTON (AP) – NASA is zeroing in on the asteroids it wants to capture, haul near the moon and have astronauts visit. A prime candidate is a tiny asteroid that whizzed about 12,200 km (7,600 miles) above Earth in 2011. At 6 m (20 ft) long, "the size of a delivery truck," designated 2011 MD. But that “asteroid” also could be a pile of smaller rocks.

NASA plans to grab a small asteroid bit with a giant claw, or to capture it with a giant inflatable bag. The asteroid would be parked above the Moon, at the L2 Lagrange point (60,000 mi) above the Moon’s "farside." with astronauts exploring in a later mission.

There will eventually be about 10 possible rocks for capture in the early 2020s, but they may not all be small asteroids. There’s a second option under consideration: sending a spacecraft to a much larger asteroid, using a claw to pluck off a boulder that’s less than 9 meters (30 feet) and taking it near to the Moon. NASA will decide which option to pursue by the end of the year.

So far, NASA has three candidates for each option, but we can expect more. A choice does not have to be made until a year before launch, which could be as early as 2019. Currently the spotlight is 2011MD, since when it came close to Earth in 2011, it was examined by telescopes on Earth and the Spitzer Space Telescope. Details of the asteroid were published in an astronomy journal. It probably weighs around 90 metric tons (100 US tons) but is so porous that about 2/3rds is empty space and only one-third is rock, in other words it is a loose boulder pile.The robotic cost of the mission would be about $1.2 billion, but there's no good estimate yet for the astronaut part, which includes using the yet-to-be-built SLS rocket.

---

**Just made Crater on Mars indicates how often small astrobits hit all planets**


New imagery from NASA’s Mars Reconnaissance Orbiter has revealed the 160-foot-wide crater, which scientists have determined was created between March 27-28, 2012. The imagery also reveals possible landslides that occurred as a result of the impact.

Do watch the Video: Conclusions from this event show how often small objects hit ALL the planets though on planets with thick atmospheres, like Earth, most of these do not hit the surface.

---

**NASA Funds 12 Futuristic Space Tech Concepts: 1 Asteroid-related**

[http://www.nasa.gov/content/wrangler-capture-and-de-spin-of-asteroids-and-space-debris/](http://www.nasa.gov/content/wrangler-capture-and-de-spin-of-asteroids-and-space-debris/)

✓ To enable capture and manipulation of asteroids and space debris while minimizing risk to the primary spacecraft, Tethers Unlimited, Inc (TUI) proposes the use of a nanosatellite–scale sub–satellite, called the Weightless Rendezvous And Net Grapple to Limit Excess Rotation (WRANGLER) System, which will capture and de–spin the space object, by combining two innovative technologies that have been developed by TUI: the GRASP deployable net capture device, and the SpinCASTER tether deployer/winch mechanism.
Successful testing of both technologies in a microgravity environment has established these technology components at mid–TRL maturity. The leverage offered by using a tether to extract angular momentum from a rotating space object enables a very small nanosatellite system to de–spin a very massive asteroid or large spacecraft. The WRANGLER system is suitable for an incremental development program that will validate the technology through an affordable test flight in which a nanosatellite launched on a rideshare opportunity would capture and de–spin the upper state used to launch it.

**Detailed Radar Image of “The Beast” Asteroid that buzzed Earth June 8th**


The nearly 366 meter (1200 ft)–wide (the length of 4 US football fields) space rock (2014 HQ124) was imaged by the Deep Space Network antenna at Goldstone, California and two other telescopes using a technique were one antenna beams the radar signal at the asteroid and the other antennas receive the data. The technique delivered the most detailed radar images of a near–Earth asteroid ever obtained. Its nearest approach to Earth was ~776,000 miles (3 times farther out than the Moon) and was nicknamed the ‘Beast’ by astronomers. Shown below is the best frame.

![Image of The Beast Asteroid](http://www.space.com/26238-beast-asteroid-radar-photos-video.html)

**Rosetta’s Target Comet is Becoming Active**

http://www.esa.int/Our_Activities/Space_Science/Rosetta/Rosetta_s_target_comet_is_becoming_active


May 15, 2014 – comet 67P/Churyumov–Gerasimenko, the target of ESA’s Rosetta mission, has started to reveal its true personality as a comet, with its dusty veil clearly developing over the last six weeks. This is to be expected as it gets closer to the Sun and its ice–rock surface begins to heat up.

Animated image: http://www.esa.int/var/esa/storage/images/esa_multimedia/images/2014/05/comet_develops_a_coma/14524459-1-eng-GB/Comet_develops_a_coma_large.gif

The sequence of images presented in this image were taken between 27 March and 4 May, as the gap between craft and comet closed from around 5 million km to 2 million km (3–1 million mi). By the end of the sequence, the comet’s dusty ‘coma’ extends some 1300 km (800 mi) into space. By comparison, the nucleus is roughly only 4 km (2.5 mi) across, and cannot yet be ‘resolved’.

![Image of Rosetta's Comet](http://www.esa.int/var/esa/storage/images/esa_multimedia/images/2014/05/comet_develops_a_coma/14524459-1-eng-GB/Comet_develops_a_coma_large.gif)

Rosetta’s path: Full size image: http://static.guim.co.uk/sys-images/Guardian/Pix/pictures/2014/1/20/1390240703787/rosettaLocatorWeb.png
The comet is still more than 600 million km (370 million mi) from the Sun – more than four times the distance between Earth and Sun – its surface is already warming, causing surface ices to sublimate and gas to escape from its rock-ice nucleus. This gas carries a cloud of tiny dust particles out into space, slowly expanding to create the coma (tail). Rosetta and the comet it is chasing will be closest to the Sun in August 2015, between the orbits of Earth and Mars.

Catching this phenomenon early allows scientists to study dust production and structures within the coma before getting much closer. Only a few months from now, Rosetta will be deep inside this cloud of dust. Tracking the periodic changes in brightness has already revealed that the nucleus is rotating every 12.4 hours – about 20 minutes shorter than previously thought. These early observations help to develop models of the comet that will be essential to guiding Rosetta’s approach when it gets closer.

OSIRIS and the spacecraft’s other dedicated navigation cameras have been regularly acquiring images to help determine Rosetta’s exact trajectory relative to the comet to slowly bring it in line with the comet before making its rendezvous in the first week of August.

Left: Rosetta space craft with lander on its back   Right: The Philae Lander

Detailed observations will help find the best location on the comet for the Philae lander in November. As the probe gets closer, we should get many photos of the awakened comet itself. ##

**NASA Funds 12 Futuristic Space Tech Concepts: 1 Comet–related**

June 4, 2014 – **Comet Hitchhiker:** Harvesting Kinetic Energy from Small Bodies to Enable Fast and Low–Cost Deep Space Exploration


Illustrations:  http://www.nasa.gov/sites/default/files/capabilities.jpg  http://www.nasa.gov/sites/default/files/scenario2.jpg

**Description**

The comet hitchhiker **would hitch rides on comets to tour around the Solar System.** A tethered spacecraft accelerates or decelerates itself without fuel by harvesting kinetic energy from a target body.

✓ **The spacecraft harpoons a target** as it makes a close flyby in order to attach a tether to the target.

✓ **As the target moves away,** it reels out the tether while applying regenerative brake to give itself a moderate (<5g) acceleration as well as to harvest energy.

(Imagine a fisherman on a small boat tries to catch a big fish that runs at a high relative speed. Once the fish is on a hook, the experienced fisherman would let the line go while applying a moderate tension on it, instead of holding it tightly. If the line has a sufficient length, the boat can eventually catch up with the fish with moderate acceleration.)

✓ **Three novel capabilities:**

1. **Fuel–less landing and orbit insertion.** ... a comet hitchhiker spacecraft can obtain up to ~10 km/s of delta–V by using a carbon nanotube (CNT) tether. This ... enables a spacecraft to land on/orbit around never–visited long–period comets and Kuiper belt objects (KBOs). Now only a fly–by is realistic.

2. **Non–gravitational slingshot around small bodies.** A comet hitchhiker can obtain ~5 km/s of additional delta–V by utilizing just 25% of the harvested energy for reeling in the tether and/or driving electric propulsion engines. The tether is detached from the target after the desired delta–V is obtained. This concept enables a fast trajectory to a wide range of destinations by taking full advantage of the high relative velocity, abundance, and orbital diversity of small bodies. By hitching a comet with q=0.5 AU, a comet hitchhiker can reach the current orbital distance of Pluto (32.6 AU) in 5.6 years and that of Haumea (50.8 AU) in 8.8 years.
3. **Deep space energy production.** Assuming 25% efficiency of regenerative brake, a 2-ton comet hitchhiker can produce ~25 GJ of energy, which is sufficient to drive an instrument with 1 kW power consumption over 290 days. If future storage device can achieve the energy density of gasoline, 25 GJ can be stored in 500 kg of mass, making it a potential energy source in the outer Solar System.

- **Science missions enabled by the comet hitchhiker concept are not only intellectually exciting but also crucial to achieve a NASA's strategic goals.** Three particular examples of such missions are:
  1. Exploration of primitive bodies, with chemical compositions from the formation of the Solar System,
  2. In-depth observation of KBOs, and

- **All of the three science missions require a level of delta-V in deep space that is impractical or extremely costly using currently available technologies.** Our concept brings important advantages over a related concept of tether-based flyby, which uses a fixed length of tether in order to change the direction of the relative velocity like gravity assist.

- **This concept cannot be used for landing and orbit insertion** because it does not reduce the relative speed. The comet hitchhiker concept is distinct in that it reels out a tether while applying regenerative brake force to accelerate itself, and at the same time, to harvest energy. This approach allows the spacecraft to match its velocity with that of the target, and as a result, enables soft landing on and orbit insertion around unexplored bodies such as long-period comets and KBOs. The comet hitchhiker concept will advance the frontier of space exploration to the most exotic worlds in the Solar System.

---

**Earth Impact: Are Comets a Bigger Threat than Asteroids?**


June 18, 2014 – Discussions about “death from above” scenarios usually center on asteroids, but a comet impact could be far more devastating than a space rock strike.

- **Near-Earth asteroids** (NEAs) have Earth-like orbits, so their collisions with Earth tend to be glancing blows from behind or from the side.

- But **comets travel around the Sun in more random paths and can thus slam into the planet head-on, with potentially catastrophic results:** a much bigger crater, much more damage.

- Comets can travel up to three times faster than NEAs relative to Earth at the time of impact. **The energy released by a cosmic collision increases as the square of the incoming object's speed,** so a comet could pack nine times more destructive power than an asteroid of the same mass. Further, a comet’s higher speed means that a dangerous one could be nearly upon Earth by the time it is detected.

  - **[Editor: Given the comet's brighter tail, it seems unlikely that we would have no warning, unless the comet comes from a sunward direction, hitting the part of Earth that is enjoying daytime. Add cloudy skies and we might not know what hit us.]**

- In some cases, people have said that we may have two years’ or so warning, but scientists and engineers would prefer even more lead time to keep Earth out of harm’s way.

- One of the most promising deflection strategies involves launching a robotic probe to rendezvous with and fly alongside of the incoming object, nudging it off course via a slight but persistent gravitational tug. This "gravity tractor" method obviously cannot work overnight.

- Adding to the intrigue and the danger is the unpredictability of cometary orbits. The icy objects begin spouting gas as they near the Sun and heat up; these gas jets act like little thrusters that can alter a comets path, making predictions more difficult.

  - **This said, the focus on asteroids as Earth's primary impact threat is not misplaced, simply because they vastly outnumber comets.** "The likelihood of an impact from an asteroid is probably 100 times the likelihood of an impact from a comet of the same size."

- While there are probably trillions of comets out there, the vast majority of them reside at the extreme outer edge of the solar system, in a shell of icy bodies known as the Oort Cloud. Near-Earth space, meanwhile, is dominated by asteroids. Scientists think millions of NEAs exist, but only about 11,000 have been discovered and tracked so far. **##**
MERCURY

**Explosive Surprise: Huge Volcanoes Shook Mercury for Billions of Years**

Explosive volcanic eruptions apparently shaped Mercury's surface for billions of years — a surprising finding, given that until recently scientists had thought the phenomenon was impossible on the sun-scorched planet.

![Mercury volcanoes](http://www.space.com/images/i/000/038/501/original/Mercury1.preview.jpg?1397522128)

Two pyroclastic vents on the floor of Mercury's Kipling crater, left, would likely not have survived the impact; they are more recent. The false color image of the same spot, right, marks pyroclastic material as brownish red. Credit: Brown University

Could this discovery shed new light on the origins of Mercury? On Earth, explosive volcanic eruptions can lead to catastrophic damage, such as when Mount St. Helens detonated in 1980 in the deadliest and most economically destructive volcanic event in U.S. history. [But there have been far greater eruptions: Krakatoa in 1893, for example. And then there are a few “super volcanoes, such as Yellowstone, which can easily devastate a million square miles. Yellowstone pops its lid about every 700,000 years and is now “overdue.”]

Explosive volcanism happens because Earth's interior is rich in volatiles — water, carbon dioxide and other compounds that vaporize at relatively low temperatures. As molten rock rises from the depths toward Earth's surface, volatiles dissolved within it vaporize and expand, increasing pressure so much that the crust above can burst like an overinflated balloon.

Mercury was long thought to be bone-dry when it came to volatiles. As such, researchers thought explosive volcanism could not happen there. However, in 2008, after the initial flyby of Mercury by NASA's Messenger orbiter (short for MERCury Surface, Space ENvironment, GEochemistry, and Ranging), researchers found unusually bright reflective material dotting the planet's surface.


This appears to be pyroclastic ash from volcanic explosions. The large number of these deposits suggested that Mercury's interior could not always have been devoid of volatiles, as had long assumed.

It was unclear from MESSENGER's first flybys over what time periods those explosions had occurred. Now scientists find Mercury's volatiles did not escape in a rash of explosions early in the planet's history. Instead, explosive volcanism apparently lasted for billions of years. (Mercury, like the other planets, was formed about 4.5 billion years ago.)

Investigators analyzed 51 pyroclastic sites across Mercury's surface using data collected by MESSENGER collected since it began orbiting the planet in 2011. These orbital readings provided a far more detailed view of the deposits and the vents that spewed them than the data from the initial flybys.
Some of the vents appear to be much more eroded than others. Evidently the explosions did not all happen during the same period. If they had, we'd expect all the vents to be similarly degraded. But we see different degradation states. The eruptions appear to have been taking place over an appreciable period of Mercury's history. About 90% of these ash deposits are located within craters formed by meteorite impacts. These deposits must have accumulated after each crater formed, or they would have been destroyed by the impact that formed the crater.

**VENUS**

**Europe's Venus Express Prepping for Daring Dive into Venus' Atmosphere**


Visualization of Venus Express during the aerobraking maneuver, which will see the spacecraft orbiting Venus at an altitude of around 130 km from 18 June to 11 July. If the spacecraft survives and fuel permits, it will be raised back up to approximately 450 km, allowing operations to continue for a few more months. Eventually, however, the spacecraft will plunge back into the atmosphere and the mission will end.

A European spacecraft will plunge into Venus' thick atmosphere in June in a bold maneuver that could bring its long and productive mission to a dramatic end. Venus Express has been circling Earth's hellish "sister planet" for eight years, and is running low on fuel. Mission officials have wrapped up routine science operations to begin preparing Venus Express for a deep dive into the planet's fast-swirling air.

ESA had performed previous short 'aerodrag' campaigns where the probe skimmed the thin upper layers of the atmosphere at about 165 kilometers [103 miles], but they wanted to go “perhaps as deep as 130 kilometers [81 miles], maybe even lower, to gain new insights, not only about usually inaccessible regions of the planet's atmosphere, but also how the spacecraft and its components respond to such a hostile environment. Venus Express will take temperature and pressure measurements and gather other science data during the dive from June 18 through July 11.

The "aerobraking" maneuver will have other benefits as well. This exercise provides the opportunity to develop and practice the critical operations techniques required for aerobraking, an experience that will be precious for the preparation of future planetary missions that may require it.

**Eight productive years**

Earth and Venus are about the same size and formed at roughly the same time. But Venus is a much more inhospitable world than our own, with surface temperatures topping 450 °C (840 °F) and a super-dense atmosphere composed of toxic gases.

Venus Express launched in November 2005 and arrived at Venus in April 2006. Its orbit is extremely elliptical, taking the probe as close to the planet as 250 km (155 miles) and as far away as 66,000 km (41,000 miles). It’s seven science instruments gathered much information about Venus’ atmosphere and surface. It spotted flashes of lightning in the sulfuric-acid clouds and determined that wind speeds mysteriously increased from 300 km/h (186 mph) to 400 km/h (250 mph).

The mission's infrared measurements also suggest that Venus might have had a system of plate tectonics in the past, as Earth does today, as well as an ocean of liquid water. Other observations indicate that the planet was likely volcanically active as recently as 2.5 million years ago, and may still be so today.
The probe has taught us how variable the planet is on all timescales and has given us clues as to how it might have changed since its formation 4.6 billion years ago. Earth and Venus have lead such dramatically different lives, but we've also noticed that there are some fundamental similarities.

The end is near

Venus Express may not survive the upcoming deep dive, but if it does, the probe's handlers will boost its orbit once again and command it to keep gathering data for a few more months, until its fuel runs out. Whatever happens, Venus Express’ mission will likely be over by the end of the year, after teaching us far more than we could have expected. ##

JUPITER

JUPITER’S MOONS: Europa & Ganymede

Deep Dive Challenges Origin–of–Earth–Life Theory: Implications for Chances of Life on EUROPA and similar moons  

April 9, 2014 – We still don’t know how life began, but we may know how it didn’t. Researchers who tested the popular theory that life originated around ancient seafloor hot springs have discovered that may not be what happened. The study, published in the Proceedings of the National Academy of Sciences, describes how scientists analyzed the chemicals spewing from deep-sea geysers and found very little methanethiol, CH3SH, a compound suspected to be the “starter dough” from which all life emerged.

![Methanethiol](http://en.wikipedia.org/wiki/Methanethiol)

Life still could have started around seafloor vents, but if so, methanethiol most likely was not involved.

Left: collected fluids from black smokers  Right: chain of deep sea vents and “smokers”

One of our greatest mysteries is how life originated on Earth. Scientists have determined that life began roughly 3.8 billion years ago, but there is still intense debate about exactly “how” life began. One possibility has grown in popularity in the last two decades – that simple metabolic reactions emerged near ancient seafloor hot springs, enabling the leap from a non-living to a living world.
Recent research by geochemists Eoghan Reeves, Jeff Seewald, and Jill McDermott at Woods Hole Oceanographic Institution (WHOI) is the first to test a fundamental assumption of this ‘metabolism first’ hypothesis, and finds that it may not have been as easy as previously assumed. Instead, their findings are relevant for the search for life on other planets.

In 1977, scientists discovered biological communities unexpectedly living around seafloor hydrothermal vents, far from sunlight and thriving on a chemical soup rich in hydrogen, carbon dioxide, and sulfur, spewing from the geysers.

Inspired by these findings, scientists later proposed that hydrothermal vents provided an ideal environment with all the ingredients needed for microbial life to emerge on early Earth. A central figure in this hypothesis is a simple sulfur-containing carbon compound called “methanethiol” – a supposed geologic precursor of the Acetyl-CoA enzyme present in many organisms, including humans. Scientists suspected methanethiol could have been the “starter dough” from which all life emerged.

However: The question Reeves and his colleagues set out to test was whether methanethiol—a critical precursor of life—could form at modern day vent sites by purely chemical means without the involvement of life. In other words, could methanethiol be the bridge between a chemical, non–living world and the first microbial life on the planet?

Carbon dioxide, hydrogen and sulfide are the common ingredients present in hydrothermal black smoker fluids. “The thought was that making methanethiol from these basic ingredients at seafloor hydrothermal vents should therefore have been an easy process,” adds Reeves.

This appealing theory “solved” many of the basic problems with rival ideas that life may have been carried to Earth on a comet or asteroid; or that genetic material emerged first—the “RNA World” hypothesis. But when we actually start to test this ‘metabolism first’ idea in the natural environment, by using modern vents as analogs for those that were around when life first began, the scientists were surprised by what they found.

To directly measure methanethiol, the researchers went to hydrothermal vent sites where the chemistry predicted they would find abundant methanethiol, and others where very little was predicted to form. In total, they measured the distribution of methanethiol in 38 hydrothermal fluids from multiple differing geologic environments including systems along the Mid-Atlantic Ridge, Guaymas Basin, the East Pacific Rise, and the Mid-Cayman Rise over a period between 2008 and 2012.

As some systems are very rich in hydrogen, and when you have a lot of hydrogen it should be very easy to make a lot of methanethiol. The fluids were collected in isobaric gas–tight samplers (IGTs) which maintain fluids at their natural pressure and allow for dissolved gas analyses.

Instead of an abundance of methanethiol, the data collected in the hydrogen–rich environments showed very little was present. Apparently, it does not matter how much hydrogen you have in black smoker fluids, you don’t seem to be making a lot of methanethiol where we expected a lot of it to be formed. Quite the contrary, in the low–hydrogen environments, where much less should form, the research actually found more methanethiol than predicted, totally contradicting the original idea of how methanethiol forms. Overall, this means that jump–starting proto–metabolic reactions in hydrogen–rich early Earth hydrothermal systems through carbon–sulfur chemistry would likely have been much harder than many had assumed.

Researchers found an abundance of methanethiol formed in low temperature fluids (below about 200°C), where hot black smoker fluid mixes with colder sea water beneath the seafloor. The presence of other telltale markers in these fluids, such as ammonia—a byproduct of biomass breakdown—strongly suggests these fluids are ‘cooking’ existing microbial organic matter. The breakdown of existing subseafloor life when conditions get too hot may therefore be responsible for producing large amounts of methanethiol.

What they found is that methanethiol is not formed by purely chemical means without the involvement of life. The finding that methanethiol may be readily forming as a breakdown product of microbial life provides further indication that life is present and widespread below the seafloor.

This new understanding could change how we think about searching for life on other planets.

On the upside, we now have a pretty simple marker for life. Someday if we can land a rover on the ice-covered oceans of Jupiter’s moon Europa—another place in our Solar System that may host hydrothermal vents, and possibly life—and successfully drill through the ice, the first thing it should probably try to measure is methanethiols. “This is already something scientists are thinking about, and it is exciting to think this might even happen in our life time.”

As for the search for the origins of life, Reeves agrees that hydrothermal vents are still a very favorable place for life to emerge, “but maybe methanethiol was not the starter dough.” While the hydrothermal environment is still a perfect place to support early life, the question of how it all started is still open.” #
NASA has issued a Request for Information (RFI) to science and engineering communities for ideas for a mission to Europa that could address fundamental questions of the enigmatic moon and the search for life beyond Earth.

The RFI's focus is on concepts for a mission to Europa that costs less than $1 billion, excluding the launch vehicle that can meet as many of the science priorities as possible recommended by the National Research Council's 2011 Planetary Science Decadal Survey for the study of Europa. NASA wants to hear from creative teams with ideas on how to achieve the most science at minimum cost.

"Europa is one of the most interesting sites in our solar system in the search for life beyond Earth. The drive to explore Europa has stimulated not only scientific interest but also the ingenuity of engineers and scientists with innovative concepts."

NASA has already studied a variety of mission designs and concepts and is currently funding the development of technologies needed for the science instruments for a Europa mission. Congress appropriated $80 million for this work in Fiscal Year 2014, and the Fiscal Year 2015 budget proposal requests an additional $15 million.

We have already determined the existence of a liquid water ocean located under the moon's ice crust that covers Europa entirely and contains more liquid water than all of Earth's oceans combined. The Decadal Survey ranks a mission to Europa as of NASA's highest priority scientific pursuits.

The mission will need to:
1. Characterize the extent of the ocean and its relation to the deeper interior
2. Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface–ice–ocean exchange
3. Determine global surface, compositions and chemistry, especially as related to habitability
4. Understand the formation of surface features, including sites of recent or current activity, identify and characterize candidate sites for future detailed exploration
5. Understand Europa's space environment and interaction with the magnetosphere.

Although Europa and Jupiter's other moons have only been visited by other spacecraft limited to a single distant flyby. NASA's Galileo spacecraft, launched in 1989 was the only mission to make repeated visits to Europa, passing close by the moon fewer than a dozen times.

Any mission to Europa must take into account the harsh radiation environment that would require unique protection of the spacecraft and instruments. In addition, spacecraft must meet planetary protection requirements intended to protect Europa's potentially habitable ocean. These requirements are very strict and involve ensuring that a viable Earth organism is not introduced into the Europa ocean. ##

### Hunt for Alien Life May Focus on Europa’s Water Vapor Plumes

The Hubble Space Telescope’s cosmic firepower was recently put to a new purpose: searching for a billowing clouds of water vapor on Europa. The plumes are a sign that extraterrestrial life could be lurking within our own solar system.

Before we head way out there, we need to know a little about the eruptions happening at home. On Earth, such plumes are a hallmark of energy in motion, active geology in the form of pyroclastic eruptions which include solid rock, semi-solid fragments and hot gases expelled from the mantle through areas of weakness in the crust.

Even when volcanos are underwater, as many are, they send up steaming columns of lava fragments, bits of rock and heated gas. These underwater plumes of hot material rise hundreds of meters. Heated gases escape from the interior and reach the surface. There, they rapidly expand and cool, dissipating the fierce energies that drove them to erupt. Thus volcanism reflects the build-up of pressure within a planet or other large body on which it is known to occur.

In March of 2006, geysers were discovered spewing water from the surface of Enceladus, one of Saturn’s icy moons. How can a moon with surface temperatures of –201° C (–330° F) have active geology? Could these phenomena signal a warm core for Enceladus and other icy moons?
Plumes on exo-planets far away

Cryoclastic plumes may play a key role in finding superhabitable zones in areas around gas giants – places where tidal forces create enough heat to sustain life. On Earth, similar phenomena involves warm water. Warm, in this case, is relative. NASA’s Cassini probe, noticed that the area around these vents is substantially warmer than the surrounding ice: as high as 190°K (−120°F.) Where pyroclastic explosions emit fragments of broken fire, cryoclastic eruptions are bursts of icy material that are hundreds of degrees warmer than the surrounding surface, but still well below freezing.

Another point of difference between Earth’s plumes and icy world plumes is contents. Enceladus’ plumes spew water vapor and dust, which rapidly disperse into surrounding space. Then, there’s the point of origin. There are no volcanoes on Enceladus. Instead, these plumes originate from vents in the southern polar terrain, also known as “tiger stripes.” Now, at least two of the ingredients necessary for life are present on Enceladus: water and warmth.

But the existence of relatively warm vents and escaping water do not prove that active heating is occurring deep within the moon, or that an ocean lies within its ice sheet. Local radioactivity and flexing forces from Saturn may be creating underground liquid reservoirs in the regions around the vents. That would raise temperature in just that region, melting ice that could then pool into the cracks. If this were true, water vapor plumes on Enceladus might originate relatively near the surface, instead of from a life-breeding ocean.

The discovery of the plume on Enceladus was sufficient to prove that icy moons undergoing tidal forces are geologically active. Europa, circling Jupiter, has all of ingredients for life as well: an extremely thick ice sheet, a saltwater signature and possibly an enormous ocean with twice as much water as all of Earth’s oceans combined. Organic material has been found on the surface. The surface itself is known to undergo continual remodeling, bringing organics down and any subsurface life-signatures up. Many scientists believed that if plumes could be found on Europa, that would be a portent that we should head there to look for further signs of life. Recently, the Hubble Space telescope happened to be looking right at Europa the moment a plume exploded.

Elusive Eruptions: Europa vs. Enceladus

Plumes on Europa could be tough to catch in the act. You want to look at the limb where the edge of the moon meets the dark space of space. On smaller Enceladus, plumes remain suspended for a time. By contrast, the expulsion of water vapor into the near-vacuum surrounding Europa is short-lived. Europa’s more substantial gravity yanks the frozen water spouts back toward the surface. Ice lands on ice, leaving barely a trace. So the only chance to catch a plume on Europa is to look at the disc and the limb, and keep looking until one happens right in front of us. The wait could be quite long for a human.

The Hubble Space Telescope is currently the only tool powerful enough to crane its neck at just the right angle to catch a transient puff of the water vapor 640 million km (400 million m) away. Even so, Hubble hunted for a plume on Europa for years before finally catching one using its spectrograph. Caught on Camera in invisible light

A spectrograph separates light into color components by wavelength. They are invaluable in astronomy. Objects in space that can’t be seen with visible light can still be detected by the radiation around them. Hubble’s Space Telescope Imaging Spectrograph (STIS) allows it to detect black holes. In Europa’s case, the STIS picked up the plume’s vapor cloud by its ultraviolet light, which is just beyond what’s visible to the eye.

The plume of water vapor seen by Hubble in December 2012 extended more than 200 km (125 miles) into space. This suggests that some areas of Europa’s crust are being intensely heated to create the vapor.

“We can’t say for sure yet whether this is a cyclical process or a chance event, or whether the vapor is coming from warm but solid ice, partially-melted ice, or from the ocean, but it’s definitely a sign that Europa has some exciting internal activity going on right now.”

Putting On the Gloves

We are uncertain how water gets just below the surface of Europa. But we have many models about how, and quite a few notions about when. “At apocenter, the surface fractures in the south polar region experience tension. This tension might open the cracks and allow the water vapor to escape from a subsurface liquid reservoir,” said Lorenz Roth, first author on the Science paper that described the plume’s discovery. “Confirmation of the initial detection and the proposed connection to Europa’s orbital position is crucial now.”
Using Hubble to look for further plumes during the entire orbit will bring us closer to some answers. However, we won’t truly understand what’s going on inside Europa’s salty oceans, possibly warm for the last 4 billion years, until we take a much, much closer look.

But this vapor plume is right at the limit of what telescopes near Earth can see. “To really get to the bottom of this story, we need to send a spacecraft to Europa.”

With plumes, water vapor bursts through the ice shell and arches away at amazing speed. The resulting ballistic arc of freezing droplets can be seen from half a million miles away. Better still, they can be sampled without having to land, drill, melt or dig. “There’s a very good chance that we can sample the material in five to 10 or 15 years.” Now that we know when and where Europa is active, a mission can be launched with plumes specifically in mind.

A spacecraft in a low enough orbit could fly through the plume. 

Editor: This is an exciting prospect. However having the spacecraft in just the right orbit at just the right time may be asking for too much good luck – unless the plume eruption lasts long enough for us to change the spacecraft’s orbit. The time delay between Earth and the Jupiter system will make that difficult. However if the plume eruption is reoccurring, and from the same spot in Europa’s crust, we could get lucky.

38 images of Europa

Ganymede’s “Club Sandwich Ocean” could Potentially Support Life


Ganymede, the largest moon of Jupiter and also in the solar system, a might have several layers of oceans between several layers of ice, according to new NASA-funded research that models the moon’s makeup. Up until now, Ganymede was thought to harbor a thick ocean sandwiched between just two layers of ice, one on top and one on bottom.

Ganymede’s ocean might instead be organized like a multi-tiered Dagwood sandwich. The results support the idea that primitive life might have possibly arisen on the icy moon. Places where water and rock interact are important for the development of life; for example, it's thought that life may have begun on Earth in bubbling vents on our sea floor.

Previously, Ganymede's rocky sea bottom was thought to be coated with ice, not liquid -- a problem for the emergence of life. The "club sandwich" findings suggest otherwise: the first layer on top of the rocky core might be salty water. Ganymede’s ocean is huge, with enormous pressures, so it was thought that dense ice had to form at the bottom of the ocean. When we added salts to our models, we came up with liquids dense enough to sink to the sea floor."

NASA scientists first suspected an ocean in Ganymede in the 1970s, based on models of the large moon. In the 1990s, Galileo flew by Ganymede and confirmed the moon's ocean, some hundreds of miles thick. The spacecraft also found evidence for salty seas, likely containing the salt magnesium sulfate.

Previous models of Ganymede’s oceans assumed that salt didn't change the properties of liquid very much with pressure. Vance and his team showed, through laboratory experiments, how much salt really increases the density of liquids under the extreme conditions inside Ganymede and similar moons.

The models get more complicated when the different forms of ice are taken into account. The ice that floats in your drinks is called "Ice I." It’s the least dense form of ice and lighter than water. But at high pressures, like those in crushingly deep oceans like Ganymede’s, the ice crystal structures become more
compact. The ice can become so dense that it is heavier than water and falls to the bottom of the sea. The densest and heaviest ice thought to persist in Ganymede is called “Ice VI.”

Computer modeling suggests an ocean sandwiched between up to three ice layers, in addition to the rocky seafloor. The lightest ice is on top, and the saltiest liquid is heavy enough to sink to the bottom. What's more, the results demonstrate a possible bizarre phenomenon that causes the oceans to “snow upwards.”

As the oceans churn and cold plumes snake around, ice in the uppermost ocean layer, called "Ice III," could form in the seawater. When ice forms, salts precipitate out. The heavier salts would thus fall downward, and the lighter ice, or "snow," would float upward. This "snow" melts again before reaching the top of the ocean, possibly leaving slush in the middle of the moon sandwich.

Ganymede is one of five moons in our solar system thought to support vast oceans beneath icy crusts. The other moons are Jupiter's Europa and Callisto and Saturn's Titan and Enceladus. The European Space Agency is developing a space mission, called JUpiter ICy moons Explorer or JUICE, to visit Europa, Callisto and Ganymede in the 2030s. NASA and JPL are contributing to three instruments on the mission, which is scheduled to launch in 2022 – http://www.jpl.nasa.gov/news/news.php?release=2013-069

18 Images of Ganymede

SATURN'S MOONS: Titan, Enceladys, Lapetus, and a “new moonlet abirthing”

Casasini images Titan's Sand Dunes
www.esa.int/spaceinimages/Images/2014/04/Cassini_captures_familiar_forms_on_Titan_s_dunes

April 2, 2014 – In this new radar image from the Cassini orbiter we see dark streaks carved into dunes similar to some we might find on a beach on Earth, or like the raked lowing lines in a Japanese Zen garden — but this scene is actually on Saturn’s moon Titan.

Sand on Earth is composed of silicates, but the ‘sand’ of these alien dunes is formed from grains of organic matter about the same size as particles of our beach sand. The flowing lines carved into these dunes show up as dark to the human eye.

These grains are shunted around by shifting winds shifting over Titan’s surface. – winds that move slowly - 1 m/s — piling up in certain places over time.

Titan seems to be full of features and phenomena that quite familiar to features found on Earth. Over the past Cassini nine years, scientists have been studying the similarities between Titan and Earth by exploring sand dunes, channels and lakes of liquid ethane and methane scattered across its surface.

While previous images have spotted patterns on Titan’s dunes, this new image obtained by Cassini’s Titan radar mapper on 10 July 2013, shows them in greater detail.

The Cassini-Huygens mission is a cooperative project of NASA, ESA and Italy's ASI space agency.
http://lasp.colorado.edu/~horanyi/graduate_seminar/Radar.pdf
Titan Aerial Daughtercraft (Larry Matthies, NASA's Jet Propulsion Laboratory [JPL])

Titan has become one of the most fascinating bodies in the Solar System. It is the richest laboratory in the solar system for studying prebiotic chemistry, which makes studying its chemistry from the surface and in the atmosphere one of the most important objectives in planetary science.

The diversity of surface features on Titan related to organic solids and liquids makes long-range mobility with surface access important. This has not been possible, because mission concepts to date have had either no mobility (landers), no surface access (balloons and airplanes), or low maturity, high risk, and/or high development costs for this environment (e.g. large, self-sufficient, long-duration helicopters).

We propose a mission study of a small (< 10 kg) rotorcraft that can deploy from a balloon or lander to acquire close-up, high resolution imagery and mapping data of the surface, land at multiple locations to acquire microscopic imagery and samples of solid and liquid material, return the samples to the mothership for analysis, and recharge from an RTG on the mothership to enable multiple sorties.

Prior studies have shown the feasibility of aerial mobility on Titan for larger aircraft, from 10 to 400 kg, but none of these studies were in the size range we address and none addressed the daughtercraft, sampling, and recharging scenarios we address. This concept is enabled now by recent advances in autonomous navigation and miniaturization of sensors, processors, and sampling devices. It revolutionizes previous mission concepts in several ways.

For a lander mission, it enables detailed studies of a large area around the lander, providing context for the micro-images and samples; with precision landing near a lake, it potentially enables sampling solid and liquid material from one lander.

For a balloon mission, it enables surface investigation and sampling with global reach without requiring a separate lander or that the balloon be brought to the surface, which has potential for major cost savings and risk reduction.

Both scenarios can involve repeated sorties due to the recharge capability. Our phase 1 study activities will

1. develop mission concepts of operations for deployment from a lander or balloon to acquire context imaging and mapping data, to sample from solid surfaces and/or lakes, and to return to the mothership to deposit samples and/or recharge;
2. develop a parametric sizing model of the daughtercraft to characterize propulsion, power, range, endurance, and payload capability for total daughtercraft mass ranging from approximately 1 to 10 kg;
3. develop a conceptual design and identify representative components for the entire daughtercraft hardware and software system for autonomous mobility, including estimates of approximate mass, power, and energy budgets and producing a representative CAD model; and
4. develop a conceptual design and preliminary CAD model for a science payload on the daughtercraft, including specifying a nominal instrument suite on the balloon or lander, designing a compatible sampling mechanism to acquire solid and/or liquid samples on the daughtercraft, and studying mechanisms and daughtercraft behaviors necessary to transfer the samples to the instruments. The study will be done by JPL with support from AeroVironment for rotorcraft expertise and developing the sizing model. By analyzing Titan’s surface, this mission concept may teach us volumes about prebiotic chemical evolution on a planetary surface. This concept has potential for affordable insertion into Discovery, New Frontiers, or Flagship missions and could provide a technology validation step toward larger, self-contained Titan rotorcraft missions in the future. The autonomy needed for this concept is also applicable to exciting rotorcraft mission concepts for Mars and to in-situ exploration of Enceladus. It will engage the public and has abundant, compelling opportunities for education and public outreach.

Titan Submarine: Exploring the Depths of Kraken (Steven Oleson, NASA's Glenn Research Center)

Titan is unique as the only body other than Earth with liquid lakes and seas on its surface. The Titanian seas, however, are not composed of water, but are seas of liquid hydrocarbons. What lies beneath the surface of Titan’s seas? We propose to develop a conceptual design of a submersible autonomous vehicle (submarine) to explore extraterrestrial seas. Specifically, to send a submarine to Titan’s largest northern sea, Kraken Mare.
√ This craft will autonomously carry out detailed scientific investigations under the surface of Kraken Mare, providing unprecedented knowledge of an extraterrestrial sea and expanding NASA’s existing capabilities in planetary exploration to include in situ nautical operations. Sprawling over some 1000 km, with depths estimated at 300 m, Kraken Mare is comparable in size to the Great Lakes and represents an opportunity for an unprecedented planetary exploration mission. This mission would be a logical follow–on to a Titan surface mission such as TiME (Titan Mare Explorer) or even a component of a flagship mission of multiple vehicles.

√ The mission concept will investigate a full spectrum of oceanographic phenomena:
- chemical composition of the liquid, surface and subsurface currents,
- mixing and layering in the “water” column, tides, wind and waves, bathymetry, and bottom features and composition. Measurements of all these aspects of Titan’s hydrocarbon ocean environment can only be made through focused in situ exploration with a well–instrumented craft. This investigation represents a significant advancement in our understanding of the history and evolution of organic compounds in the solar system, and hence a critical step along the path to understanding the evolution of life here on Earth and potential life elsewhere in the galaxy.

While concepts of exploring extraterrestrial oceans, specifically Titan’s, have been proposed in the past they have centered on simple suspended probes or ‘diving bells’ (Lorenz, 2009, Epperly et al., 2010.) Titan Submarine, or Titan Sub for short, will be a fully autonomous, highly capable science craft that will allow a complete exploration of what exists beneath the waves on another world. As such no one has yet envisioned what such a craft might look like, how it would operate or if it could be built; this is the conceptual mission design work we propose with Titan Sub.

√ The Titan Sub addresses NASA’s strategic goals 2, 3, and 6 by exploring the Titan environment which could hold clues to how Earth and life formed, it will create new technologies in the form of a semi–autonomous planetary submersible which could be extended to other planetary oceans, and would capture the imaginations of educators and students by sharing with them exploration of a completely new environment on a foreign world. Titan Sub will also address the NASA technology areas of Space Power and Energy Storage, Robotics and Autonomous Systems, Communications and Navigation Systems, Science Instruments and Sensors, Materials, and Thermal Management Systems. By addressing the challenges of autonomous submersible exploration in a cold outer solar system environment, Titan Sub serves as a pathfinder for even more exotic future exploration of the subsurface water oceans of Europa etc. ##

### NASA considers sending Quadcopter Drone to look for Life on Titan

**NASA considers sending Quadcopter Drone to look for Life on Titan**


NASA is considering a plan to send to Titan a quadcopter drone capable of searching for life. The drone would be capable of flying out of a lander or balloon to explore the landscape and seas. It would acquire close–up, high resolution imagery and mapping data of the surface, land at multiple locations to acquire microscopic imagery and samples of solid and liquid material, return the samples to the mothership for analysis, and recharge from an RTG on the mothership to enable multiple sorties.

If successful, the new plan could drastically change the way humans explore space. Current rovers on Mars are akin to moving laboratories, but their grounded nature means they can be rather limited when it comes to exploring terrain. The 22–pound drone under consideration would eliminate that barrier with flight capability, allegedly at much lower costs than other options.

While this kind of plan would not have been feasible even just a few years ago, advancements in drone technology and other robotics have “revolutionized” older mission concepts, meaning sending a drone capable of exploring Titan is now a real possibility. NASA could either have the drone operate out of an airborne balloon–like mothership or out of a land–based vehicle.

In a lander mission, detailed studies of a large area around the lander would be possible, providing context for the micro–images and samples. With precision landing near a lake shore, it could sample both solid and liquid substances.
A balloon mission would allow surface investigation and sampling with global reach without requiring a separate lander or that the balloon be brought to the surface. This has potential for major cost savings and risk reduction.

NASA has awarded the team $100,000 to continue working on designs for the unmanned concept, which includes a mothership outfitted with a nuclear reactor. The technology has gotten to the point where such a plan can be planned, but it still needs to be developed further. NASA hopes a launch “sometime in the 2040s” would be possible.

Editor's translation: NASA can't find money in the budget for this in the foreseeable future. Hopefully some other space agency such as ESA or JAXA can get it done two decades earlier.

'Magic Island' Appears in Seas of Titan


June 23, 2014 – A mysteriously bright anomaly winked in and out of existence on the seas of Saturn's largest moon, Titan — potentially the first time waves, bubbles or some other unknown features have been seen there. Scientists would usually call such an appearance a "transient feature," in Ligeia Mare, but it has been playfully dubbed "Magic Island" – circled in photo below

[Full size image: http://i.space.com/images/i/000/040/201/original/titan-seas-anomaly.jpg](http://i.space.com/images/i/000/040/201/original/titan-seas-anomaly.jpg)

Titan is unique (so far) in having liquid methane and ethane lakes and seas, making it the only other world in the solar system that has stable liquids on its surfaces. It not only has lakes and seas, but also rivers and even rain. It has what we call a hydrological cycle, and it's the only place other than Earth that we know of where we find something similar.

192 images of Titan


Sunsets on Titan Reveal the Complexity of Hazy Exoplanets


May 28, 2014 – Editor: As this story relates more to the study of Exoplanets than it does to Titan itself, we have put our condensation of this article in the STARBOUND ASTRONOMY section below.

Cassini Detects Ocean inside Enceladus

[www.spacedaily.com/reports/Gravity_measurements_confirm_subsurface_ocean_on_Enceladus_999.html](http://www.spacedaily.com/reports/Gravity_measurements_confirm_subsurface_ocean_on_Enceladus_999.html)
[www.space.com/25328-ocean-on-saturn-moon-enceladus-suspected-beneath-ice-video.html](http://www.space.com/25328-ocean-on-saturn-moon-enceladus-suspected-beneath-ice-video.html)

APRIL 3, 2014 – The Cassini spacecraft and Deep Space Network have uncovered evidence Saturn's moon Enceladus harbors a large underground ocean of liquid water, furthering scientific interest in the moon as a potential home to extraterrestrial microbes. The presence of an interior reservoir of water was suspected in 2005 when Cassini discovered water vapor and ice spewing from vents near the moon's south pole.
The gravity measurements suggest an ice outer shell and a low density, rocky core with a “regional” water ocean sandwiched in between at high southern latitudes. The diagram at right above, suggests the ocean’s location. Gravity measurements by Cassini and the Deep Space Network infer that Enceladus, which has jets of water vapor and ice gushing from its south pole as shown, also harbors a large interior ocean beneath an ice shell, as this illustration depicts. Enceladus is 504 km (313 mi) in diameter and the smallest moon yet discovered to have a hidden internal ocean.

This “regional ocean seems to be only 10 km (6 mi) =10,000 m (39,000 ft) deep and lies beneath a shell of ice 30–40 km (19 to 25 mi) thick and in direct contact with a rocky seafloor, “theoretically making possible all kinds of complex chemical reactions — such as the kind that led to the rise of life on Earth.”

The gist of this finding is that there are potentially habitable environments in the solar system in places we might never have suspected. Enceladus’ surface temperature is about –180° Celsius (–292°F) and yet under that very cold surface we find liquid water. This confirms suspicions many researchers have had about Enceladus since 2005, when NASA’s Cassini orbiter first spotted ice and water vapor spewing from fractures near the moon’s south pole. ##

Editor: This is fascinating news, of course, but leaves us hanging. Why ere this ocean and the associated water jet plumes only at the South pole of this moon? Could this placement be a result of some past impact? The changing gravitational tug on Enceladus as it orbits around Saturn in an eccentric orbit - ( ) - would not seem to explain it. The moon’s orbital eccentricity, 0.0047, would seem minimal, and as it is very close to Saturn and orbits in just under 33 hours, the fast rate at which Saturn’s gravitational pull “vibrated” could be a clue, but only if the ocean was global. So we suspect a significant impact in the south polar region, in the relatively recent past (a few million years ago?) might be the reason. Anyone have any other ideas?

118 Images of Enceladus

NASA Cassini Images May Reveal Birth of New Saturn Moon and explain the formation of the other Saturnian moons
April 14, 2014 – NASA’s Cassini spacecraft has been documenting the formation of a small icy object within the rings of Saturn that may be a new moon, and may also provide clues to the formation of the planet’s other known moons.

The disturbance visible at the outer edge of Saturn’s A ring in this image from NASA’s Cassini spacecraft could be caused by an object replaying the birth process of icy moons.
Images from Cassini's narrow angle camera taken on April 15, 2013 show disturbances at the very edge of Saturn's A ring -- the outermost of the planet's large, bright rings. One of these disturbances is an arc about 20 percent brighter than its surroundings, 1,200 km (750 mi) long and 10 km (10 mi) wide. Unusual protuberances have been observed in the usually smooth profile at the ring's edge. The arc and protuberances may be caused by the gravitational effects of a nearby object. Details of the observations were published online (April 14, 2014) by the journal Icarus.

Are moons, and planets too, formed out of original “rings?”

The object is not expected to grow any larger, and may even be falling apart. But the process of its formation and outward movement aids in our understanding of how Saturn's icy moons, including the cloud-wrapped Titan and ocean-holding Enceladus, may have formed in more massive rings long ago. It also provides insight into how Earth and other planets in our solar system may have formed and migrated away from our star, the sun.

We not seen anything like this before, the actual birth process of a new moon (or planet) from a nebula ring. Informally named Peggy, the object is (still) too small to see in images, probably no more than about 3/4ths of a kilometer (~ a half mile) in diameter. Saturn's icy moons range in size depending on their proximity to the planet -- the farther from the planet, the larger. Now many of Saturn's moons are comprised primarily of ice, as are the particles that form Saturn's rings. Based on these and other indicators, researchers recently proposed that the icy moons formed from ring particles and then moved outward, away from the planet, merging with other moons on the way.

Cassini's orbit will move closer to the outer edge of the A ring in late 2016 and provide an opportunity to study Peggy in more detail and perhaps even image the infant moonlet.

As Saturn's rings now are, in all likelihood, too depleted to make more moons, it is possible the process of moon formation in Saturn's rings has ended with Peggy. That we are observing such an infrequent event is a bonanza for astronomers who will want to learnt all they can from the rare event.

The theory holds that Saturn long ago had a much more massive ring system capable of giving birth to larger moons. As the moons formed near the edge, they depleted the rings and evolved, so the ones that formed earliest are the largest and the farthest out.

[Editor: We now know of many more smaller moons beyond Titan. But most of them could be captured asteroids.]

---

**Saturn's moon Iapetus' Weird Ridge Rained Down from Space**


[Orange marks contributed by TTSIQ editor]

[iapetus size: Diameter 1,492 km (927 mi) – Surface area 6,700,000 km² (2,587,000 sq, mi. a bit smaller than Australia or continental USA, less than a fourth the area of the Moon.](http://en.wikipedia.org/wiki/Iapetus_(moon))
Iapetus is the third-largest satellite of Saturn, 11th largest in the Solar System and the largest body known not to be in hydrostatic equilibrium. Iapetus is best known for its dramatic two-tone coloration, but discoveries by the Cassini mission in 2007 have revealed several other unusual features, such as a massive equatorial ridge that runs three quarters of the way around Iapetus. [image above]

April 24 – 2014 Astronomers think they're close to explaining how a weird feature formed on Iapetus. This moon has a 78 day orbit around Saturn, with one hemisphere constantly facing Saturn -- in the same the Moon is tidally locked with Earth -- and it has a very obvious two-tone surface.

But it is Iapetus' weird equatorial ridge of mountains that has had scientists scratching their heads. Now, with the help of 3-D maps composed from Cassini data, researchers think they have pinned down the most likely cause of the mountains.

Iapetus appears to have neither, More, the 10 km (6 mi)-high mountains are too steep to be explained away by conventional mountain-forming mechanisms. Now researchers believe that the material that formed the Iapetian mountains have "exogenic" origin: they came from space.

Researchers point to a possible collision between Iapetus and another planetary body that generated a huge quantity of debris. As the scenario unfolds, this debris settled into orbit around Iapetus' equator and eventually "rained" down from orbit, piling up to form the equatorial mountains.

Alternate theory with the same conclusion.

An alternate theory is that Iapetus had its own moonlet that eventually fell to Iapetus's surface. Both hypothesis point to the same conclusion, that Iapetus couldn't have created the mountain range without some help from up above, as Iapetus shows no signs of geologic activity such as volcanism or plate tectonics that could otherwise explain the mountains.

This ridge does not look like any other tectonic or fault structure ever seen elsewhere in the solar system, noting its perfect symmetry, and alignment with Iapetus equator, which "really demanded an almost astronomical explanation." And there is no sign of geologic activity. The mystery of this ridge has been puzzling astronomers ever since Cassini gave them an up-close view. ##

23 Images for Iapetus

URANUS

NEPTUNE

PLUTO & BEYOND

Did Pluto's Biggest Moon, Charon, Once Have a Subsurface Ocean?


NASA’s New Horizon’s probe will skim through the Pluto–Charon system next year and could help scientists figure out if Pluto’s largest moon Charon might have once harbored a subsurface ocean. Charon's icy surface may be cracked, an indication that its interior was once warm enough to support an ocean. Two frigid moons with cracks, Saturn's Enceladus and Jupiter's Europa have subsurface oceans beneath icy shells.

Could Charon have been like that sometime in the past? Charon probably could not support a liquid ocean today. But friction created by tidal forces earlier in the Pluto system’s history could have warmed Charon's interior. Fracture patterns on the surface of Charon could differ depending on the thickness of its surface ice, the structure of its interior, how easily it deforms, and how its orbit evolved.

Comparing actual New Horizons' observations of Charon to various predictions, we can see what fits best and discover if Charon could have had a subsurface ocean in its past, driven by high eccentricity.

At the moment, Charon is extremely cold like Pluto — whose surface temperatures are expected to be around –229 °C (~380 °F). If Charon had a very eccentric orbit sometime in the past, tidal forces that warmed the interior of the moon and would have caused telltale cracks in its surface.
The imagined scenario

- Charon formed after a huge impact blasted pieces of Pluto off into space. Those pieces orbited Pluto, eventually coalescing into the moons
- Strong tides would rise on both worlds as gravity between Pluto and Charon caused their surfaces to bulge toward each other, generating friction in their interiors
- This friction would have also caused the tides to slightly lag behind their orbital positions. The lag would act like a brake on Pluto, causing its rotation to slow while transferring that rotational energy to Charon, making it speed up and move farther away from Pluto.
- Charon's orbit around Pluto is very circular now, so Charon could not still harbor an interior ocean. If New Horizons finds no cracks on Charon's surface, it puts a very strong constraint on how high the eccentricity could have been and how warm the interior ever could have been. But this research exercise gives NASA a head start on the New Horizons arrival — what should we look for and what can we learn from it. We're going to Pluto and Pluto is fascinating, but Charon is also going to be fascinating.

Old Telescope Data Could Reveal Icy Pluto's Insides


Scientists are attempting to map Pluto's icy depths using old telescope data before NASA's New Horizons spacecraft coasts by the planet June 13, 2015. Researchers had found hints of frozen chemicals hidden beneath Pluto's crust in data obtained by the James Clerk Maxwell Telescope (JCMT) on Hawaii in the late 1990s. We will get a detailed look at one side of Pluto during next year’s flyby.

Using old data from JCMT’s SCUBA (Submillimeter Common–User Bolometer Array) researchers found evidence of invisible 0.85 mm waves emitted from beneath Pluto’s surface, which could be linked to a possible dry layer of frozen nitrogen and methane hidden under a dark surface patch of water ice and frozen polymers. Some researchers think that even deeper down, Pluto has liquid water, kept fluid by remnant heat from a big crash that formed its moons — if so the surface will probably look wrinkled. The flyby will be very quick and followup research will be in order.

Hubble to Search Beyond Pluto for another New Horizons Mission Target


The Hubble Space Telescope Time Allocation Committee has recommended using Hubble to search for an object the Pluto–bound NASA New Horizons mission could visit after its flyby of Pluto in July 2015. This will involve targeting a small area of sky in the direction that the probe is moving (in the direction of the constellation Sagittarius) to search for a Kuiper Belt object (KBO) to visit. The Kuiper Belt is a vast debris field of icy bodies left over from the solar system's formation 4.6 billion years ago. A KBO has never been seen up close because the belt is so far from the sun, stretching out to a distance of 8 billion km (5 billion miles) into a never-before-visited frontier of the solar system.

To discriminate between a foreground KBO and the clutter of background stars in Sagittarius, the telescope will turn at the predicted rate that KBOs are moving against the background stars. In the resulting images, the stars will be streaked, but any KBOs should appear as pinpoint objects.

If the test observation identifies at least two KBOs of a specified brightness it will demonstrate statistically that Hubble has a chance of finding an appropriate KBO for New Horizons to visit. Then it would search across a field of view roughly the angular size of the full moon, c. one arc minute.

Competition for time on the telescope is extremely intense and this request significantly exceeds the observing time available in a given year. Proposals must address significant astronomical questions that can only be addressed with Hubble's capabilities, beyond the capabilities of ground–based telescopes.

Finding a KBO is a challenging needle–in–haystack search. A typical KBO along the New Horizons trajectory may be no larger than Manhattan Island and as black as charcoal.

Precedent: Hubble was used to discover four small moons orbiting Pluto–Charon, providing new targets to enhance the mission's scientific return. And Hubble has provided the most sensitive search yet for potentially hazardous dust rings around the Pluto. Hubble also has made a detailed map of the dwarf planet's surface, which astronomers are using to plan New Horizon's close–up reconnaissance photos.

Recently Hubble discovered a new satellite around Neptune, found circumstantial evidence for oceans on Europa, and uncovered several bizarre cases of asteroids disintegrating before our eyes.
Dwarf Planet Discovery Could Help Show Life's Spread Through Solar System

On March 26, 2014, researchers announced the discovery of 2012 VP133, an estimated 450-km (280-mi) wide object just beyond the Kuiper Belt of icy objects that swarm outside Neptune’s orbit.

Nicknamed "Biden" after the vice–president of the United States, because both Joe Biden and 2012 VP133 are "VPs," it is one of only two dwarf planets discovered beyond the Kuiper Belt, with Sedna found a decade ago being the other one. "Biden" has a perihelion (closest approach to the Sun) of 80 astronomical units – 8 times as far from the Sun as is Earth.

Mapping tiny worlds at the Solar System’s edge could one day show scientists how life arose on Earth, as many of these objects could contain organics, carbon–based material that are ingredients for life.

Left: An artist's concept of the dwarf planet Eris and its moon Dysnomia. The sun is the small star in the distance. Right: The discovery images of 2012 VP113 combined into one frame. Red, green and blue dots [in the white rectangle) show its path across the sky.

As the search continues, scientists expect that 2012 VP133 will be but the first of a series of discoveries of such objects. Finding such a world has a value of its own, but the team is also thinking of a greater astrobiological question as they study 2012 VP133.

Are the possible organics — ultra-red material in telescopes — a possible source for life on Eris. One of the objectives is trying to determine the nature of this ultra-red material we find in the Kuiper Belt.

Curiously enough, 2012 VP133 has none of this material on it, than Sedna does. It will take more discoveries of such objects to figure out if this ultra-red material is common outside of the Kuiper Belt, and how organics could have been transported to Earth early in the Solar System’s history.

A treasure trove of possible organics

Most dwarf planets found to date — including Pluto, once considered a planet — reside in the Kuiper Belt, a vast collection of frozen objects that orbit our Sun about 30–50 times the distance between the Earth and the Sun. There may be millions of objects in the Kuiper Belt, but the ones that interest Sheppard and his colleagues are those that have "resonances" with Neptune, exerting gravitational influences on each other that put them into closely related orbits with periods that are in simple ratios to one another. Editor: for example 2:3, 4:5, etc.

A 2012 paper in the Astronomical Journal, "The Color Differences of Kuiper Belt Objects in Resonance with Neptune," some 58 Kuiper Belt objects are shown to be full of ultra–red material, indicating likely organics. On the edge of the belt, some of those objects also still have the material, showing that it is somehow leaking into the inner Solar System. Those that are much further away, however, show none of the material.

Sedna and 2012 VP133 are well beyond the Kuiper Belt boundaries and may be in the edges of the Oort Cloud, a theorized icy collection of objects extending thousands of AUs outward from the Sun, and the supposed source of many comets that fly into the inner solar system.

The problem is that it is difficult to figure out how dwarf planets such as Sedna and 2012 VP133 could receive ultra–red material from the Kuiper Belt because they are so far away from it. Further, it's unclear why only Sedna (of the two dwarf planets known in that region) has the material. They're too far away for Neptune to have any influence on them. So what happened? [Cf, “New Dwarf Planet Photos” http://www.space.com/25229-dwarf-planet-2012-vp113-photos-images.html]
If we can determine what resonants have and do not have ultra-red materials, we might understand how the ultra-red material has moved around the outer Solar System.

**A big jolt and clues to how the outer Solar System was formed**

It becomes clear that something big likely disturbed some of these objects. Sedna’s weird orbit got the attention of researchers because it is so eccentric. The dwarf planet ranges between 80 AU and 940 AU — meaning that one orbit takes about 11,400 years to complete. **Sedna has by far the most eccentric orbit in the Solar System.** If Earth’s orbit was so eccentric, it would wander out beyond Saturn, our oceans freezing solid in the process. Sedna probably formed much further in and somehow got perturbed in a close pass of a major planet and ended up outside the realm of the major planets.

Sheppard and Trujillo then compared Sedna’s and 2012 VP133’s orbits with 10 representative Kuiper Belt objects that have eccentric orbits. To their surprise, they found that all 12 of them had almost identical “arguments of perihelion”. an orbital parameter that measures the angle between two points in each object’s orbit: the closest approach to the Sun, and the location where the objects cross the prevailing plane of the Solar System.

They “should have” random arguments of perihelion, but the similarities point to a giant disturbance causing chaos. There are three theories for this.

1. **A rogue planet** (Earth’s size or smaller) was ejected out of the Solar System, throwing smaller objects aside as it passed into the outer Solar System. This hypothetical rogue planet could have been ejected from the Solar System or lurk out there somewhere, too far and too dim to show up in surveys, such as that by NASA’s Wide-field Infrared Survey Explorer (WISE), a spacecraft more suited to finding gas giant planets, which emit their own heat. (Of course, this planet would not be a “rogue” until it had been ejected into interstellar space.)

2. **Another star passing our own Sun** about at a distance of say 200 AU from our own caused huge gravitational disturbances. It seems easy to explain a star tugging on the wandering Sedna, but VP113 has a more circular orbit that only goes as far as 266 AU, more tightly bound to the Sun, and that argues against a stellar encounter.

3. **The Sun captured extrasolar planets** from another star early in the Sun’s history, while it was forming in a cloud of gas and young stars. relatively close to one another.

**Hundreds of objects waiting for discovery**

We need to learn more about the nature of the dark red material itself. It may be organics, but what sort of organics is of great interest. Luckily, New Horizons will pass by Pluto and its moons in 2015 before zooming toward the Kuiper Belt. After the Pluto encounter, perhaps we could direct its observations to an ultra-red object yet to be identified.

The search of the outer Solar System will continue. He and his collaborators have some suspected new objects that need confirmation, and better yet, his research estimates that there could be at least 900 objects in the Oort Cloud’s fringes that are at least a little less than half of Pluto’s size.

Some of these distant worlds might be bigger than Pluto, and possibly bigger than Mars, even bigger than Earth, waiting to be discovered. ##
For the first time, scientists observing a massive solar flare were able to study the process that created it, confirming new theories about flares and the explosive ejections of solar material often linked with them. Understanding how solar flares form is essential to learning how to predict these events and of the dangerous space weather that can damage satellites and power grids on Earth.

NASA's Solar Dynamics Observatory (SDO) spacecraft observed the massive solar flare of July 12, 2012 — less than a week after the publication of a new 3D model that suggested similar flares are driven by a process known as slipping reconnection.

The problem has been that the 2D standard solar flare model captures much of the physics involved, but has the inherent limitation of being a 2D model. And there can be no slipping reconnection in a 2D model, since it is missing the third dimension, in which the slipping motion occurs.

Bright lights on the sun

Solar flares — very intense brightenings of the Sun’s atmosphere — occur throughout the sun's 11-year activity cycle, with their frequency increasing as the cycle peaks, as it did around the 2012 event. Flares are classified by the peak X-ray flux measured at Earth. Smaller C- and M-class flares are far more numerous, with dozens of C-class flares sometimes occurring daily during solar maximum.

But the most energetic type — X-class flares, like the July 12, 2012 event — are far more rare, occurring at a frequency of at most a few per month. Some 35 times the size of Earth, the July 2012 flare lasted more than 12 hours, an unusually long duration. Less than a week before the event, a team from the University of Dundee provided a 3D simulation that showed how distortions in the Sun's magnetic field can lead to solar flares. Scientists have now extended in 3D the standard model of solar flares that has been, and still is, used to explain solar eruptive flares, completing pieces of the puzzle. This was the first time the slipping motion had been seen in a solar flare.

Scientists can't observe the sun's magnetic field lines directly, because they are theoretical lines of force. But it is possible to trace them with the material trapped in the magnetic field, similar to iron fillings you can put near a magnet. One can observe the evolution of the solar corona's magnetic field by looking at the motion of the plasma trapped in the magnetic field.

Magnetic field lines on the Sun start off smooth, stretching between two points on the visible surface known as field line footprints. As powerful convection currents rise and fall beneath them, the footprints move about, causing the field lines to twist and entangle in regions known as flux ropes. Energy begins to build in the flux ropes until the lines snap and the energy is released, creating a solar flare and sometimes launching super-hot plasma into space. With their energy gone, the magnetic field lines return to straight, low-energy states.

Slipping motion was first reported in coronal loops, not during flares. Such an event allows researchers to see not only the field lines but also the intensely heated regions of plasma that follow them, enabling scientists to confirm that what they observe is slipping field lines. Spotting such flares requires good observations, where the brightness of the event doesn't overwhelm the event being observed.

Finally, the events can occur too rapidly for either scientists or their equipment to notice them. The Atmospheric Imaging Assembly (AIA) instrument on board the SDO spacecraft is the only one capable of capturing a video with the full detail required to spot the July 2012 event. AIA captures an image every 12 seconds, whereas previous instruments, only captured an image every minute. The more-frequent images allow for a closer inspection of the fast-moving events on the surface of the sun, including the slipping motion of magnetic reconnection. In a smaller, less-energetic flare, the reconnecting action could be a greater challenge to spot, even today. ##
NASA Sees Spectacular Sun Eruption Like Never Before (Video)


EARTHBOUND TELESCOPES

NASA's Exoplanet-Hunting Kepler Space Telescope Gets New Mission


May 16, 2014 – After a year on the sidelines after an equipment failure, the Kepler Space Telescope is back in action, on a new mission, dubbed K2. Its original exoplanet hunt was cut short a year ago in May 2013 when the second of the spacecraft's four orientation-maintaining reaction wheels failed, making precision pointing impossible.

The new mission, with two years of funding, will continue exoplanet discovery, but introduces new scientific observation opportunities to observe notable star clusters, young and old stars, active galaxies, and supernovae. During K2, Kepler will stare at target fields in the plane of Earth's orbit, along the ecliptic, during observing campaigns that last about 75 days each. In this orientation, solar radiation pressure can help balance the spacecraft, making the most of Kepler's compromised pointing ability. The K2 mission is set to begin May 30.

An illustration of how K2 will work:


The $600 million Kepler mission launched in March 2009, and has been incredibly successful, detecting more than 3,800 potential exoplanets to date. ##

Cash-Starved NASA May Have to Nix 1 Space Telescope to Save Others


Based on the findings of an independent review panel, NASA has taken stock of its fleet of orbiting astrophysics telescopes and decided which to save and which to shutter.

Those “safe” include the Hubble Space Telescope, the Chandra X-Ray Observatory and the Kepler planet-hunting telescope, which will begin a modified mission designed to compensate for the recent failure of two of its four stabilizing reaction wheels.

On the chopping block are the infrared Spitzer Space Telescope, which may be deactivated due to a lack of funding. And a bid to convert data collected by the Near-Earth Object Wide-field Infrared Survey Explorer (NEOWISE) into a format usable for astrophysics was also deemed too expensive.

Congress is tightening NASA's budget, and about half of what astrophysics funding the agency does have goes to the James Webb Space Telescope (JWST), which is being readied for launch in 2018.

Last-Ditch Plan to Save Infrared Spitzer Space Telescope


WASHINGTON — The team behind the Spitzer Space Telescope, a mission reluctantly recommended for termination by a NASA-chartered panel of scientists, was set May 30 to send the agency a last-ditch proposal to keep the 11-year-old spacecraft operating, a senior project official said.

Since its cooling reservoir of cryogenic helium ran dry in 2009, the infrared telescope has been using only one of its three instruments. Spitzer's 2014 budget is about $16.5 million, and it will have to make do with less in the future now that the 2014. That means "the observatory may be running below optimum efficiency." Spitzer likely can operate through 2018. To get there, the project will have to trim its full-time staff, discontinue some engineering support services and cease efforts to make spacecraft operations more efficient. ##

THE UNIVERSE

Ancient Dwarf 'Starburst Galaxies' Shed Light on Early Universe

Dwarf Galaxies Formed More Than Their Fair Share of Universe's Stars
June 19, 2014 - New observations from the Hubble Space Telescope show small galaxies, also known as dwarf galaxies, are responsible for forming a large proportion of the stars in the universe. Studying this early epoch is critical to fully understanding how these stars formed and how galaxies grew and evolved 3.5 to 6 billion years after the beginning of the universe. There evidently is a link between a galaxy's mass and its star-forming activity, and this paints a consistent picture of events in the early universe.

Astronomers had suspected these kinds of galaxies would contribute to the early wave of star formation, but this is the first time we've been able to measure the effect they actually had, one that has been surprisingly huge. Starburst galaxies form stars at a furiously fast rate, far above what is considered by experts to be a normal rate of star formation. [in spiral galaxies such as our own “Milky Way.”]

The infrared capabilities of WFC3 have made it possible to calculate how much these low-mass dwarf galaxies contributed to the star population in our universe: they are forming stars so quickly they could actually double their entire mass of stars in only 150 million years -- an incredibly short time. Such massive growth would take most “normal” galaxies (i.e., such as our own) some 1 to 3 billion years.

This latest finding may also help to unravel the secrets of galactic evolution. Galaxies evolve through a jumble of complex processes. As galaxies merge, they are consumed by newly-formed stars that feed on their combined gases, and exploding stars and supermassive black holes emit galactic material – a process that depletes the mass of a galaxy.

It is unusual to find a galaxy in a state of starburst, which suggests to researchers starburst galaxies are the result of an unusual incident in the past, such as a violent merger.

> Galaxies churn out new stars all the time, but most of the universe's stars formed between two and six billion years after the Big Bang (13.8 billion years ago).<

The new Hubble observations capture the prolific dwarf galaxies, known as "starburst galaxies." "We already suspected that dwarf starbursting galaxies would contribute to the early wave of star formation, but this is the first time we've been able to measure the effect they actually had."

SEARCH FOR EXO-PLANETS, EXO-MOONS & LIFE

**Kepler Telescope Discovers First Earth-Size Planet in 'Habitable Zone'**

Editor: “Right size, wrong star”

http://www.space.com/25531-new-earth-size-planet-could-have-water-video.html

April 17, 2014 – Using NASA’s Kepler Space Telescope, astronomers have discovered the first Earth-size planet orbiting a star in the "habitable zone" – the range of distance from a star where liquid water might pool on the surface of an orbiting planet. The discovery of “Kepler-186f” confirms that planets the size of Earth exist in the habitable zones of some star other than our Sun.

Planes previously found in the habitable zones of various stars have been at least 40% larger in size than Earth and understanding what they are like is a challenge. Of these, Kepler-186f is more reminiscent of Earth. Its discovery is a big step toward finding worlds like our Earth. NASA’s Transiting Exoplanet Survey Satellite and the James Webb Space Telescope, are expected to discover the nearest rocky exoplanets and determine their composition, atmospheric conditions, and possible oceans – truly “Earth-like worlds.”

The size of Kepler-186f is known, but its mass and composition are not. But a planet the size of Kepler-186f is likely to be rocky. As we search for life outside our solar system we focus on finding planets with characteristics similar to Earth.

Kepler-186f lies in the Kepler-186 system, about 500 light-years from Earth in the constellation Cygnus. It has at least four companion planets, orbiting a star half the size and mass of our own, classified as an M dwarf, or red dwarf, a class of stars that makes up 70% of the stars in the Milky Way galaxy. [Editor: These stars burn their hydrogen fuel slowly, and live long, but can also flare up frequently, flooding nearby planetary space with dangerous radiation, negatively affecting their climates. M class stars are by far the most numerous. Life on worlds around these stars may not develop far, given these
challenging conditions. Planets close enough to be in the “habitable zone” may become gravitationally locked so that one side always faces its sun and is overheated, while the side facing away stays frozen. finding planets around such stars might not be a cause to celebrate."

Kepler-186f orbits its red dwarf star once every 130–days and receives one–third the energy from its star that Earth gets from the sun, placing it nearer the outer edge of the habitable zone, as Mars is in our system. On its surface, the brightness of its star at high noon is only as bright as our sun appears to us about an hour before sunset.

"Being in the habitable zone does not mean we know this planet is habitable. The temperature on the planet is strongly dependent on what kind of atmosphere the planet has. Kepler-186f can be thought of as an Earth–cousin (?) or “Mars cousin?” rather than an Earth–twin.

Four companion planets, Kepler-186b, Kepler-186c, Kepler-186d, and Kepler-186e, whiz around their sun every 4, 7, 13, and 22 days, making them too hot for life as we know it. They all measure less than 1.5 times the size of Earth.

The next steps in the search for distant life include looking for true Earth–twins -- Earth–size planets orbiting within the habitable zone of a sun-like “G Class” star -- and measuring their chemical compositions. MORE: http://www.space.com/25528-most-earthlike-alien-planets-ranking.html

Sunsets on Titan Reveal the Complexity of Hazy Exoplanets

May 28, 2014 – Cassini mission scientists have developed a new way to understand the atmospheres of exoplanets by using Saturn’s smog–enshrouded moon Titan as an example. The new technique shows the dramatic influence that hazy skies could have on our ability to learn about these alien worlds orbiting distant stars.

Light from sunsets, stars and planets can be separated into its component colors to create spectra, as prisms do with sunlight, in order to obtain hidden information. Despite the staggering distances to other planetary systems, in recent years researchers have begun to develop techniques for collecting spectra of exoplanets.

When one of these worlds transits, or passes in front of its host star as seen from Earth, some of the star's light travels through the exoplanet’s atmosphere, where it is changed in subtle, but measurable, ways. This process imprints information about the planet that can be collected by telescopes. The resulting spectra are a record of that imprint, enabling scientists to tease out details about what exoplanets are like, such as aspects of the temperature, composition and structure of their atmospheres.

Scientists exploited a similarity between exoplanet transits and sunsets witnessed by the Cassini spacecraft at Titan. These observations, called solar occultations, effectively allowed the scientists to observe Titan as a relatively nearby transiting exoplanet. It’s sunsets revealed just how dramatic the effects of hazes can be. Multiple worlds in our own solar system, including Titan, are blanketed by clouds and high-altitude hazes. Scientists expect that many exoplanets would be similarly obscured.

Clouds and hazes create a variety of complicated effects that researchers must work to disentangle from the signature of these alien atmospheres, and thus present a major obstacle for understanding transit observations. Due to the complexity and computing power required to address hazes, models used to understand exoplanet spectra usually simplify their effects.

It was unclear exactly how hazes were affecting observations of transiting exoplanets, so researches turned to relatively nearby Titan, using four observations of Titan made between 2006 and 2011 by Cassini's visual and infrared mapping spectrometer instrument. This analysis provided results that include the complex effects due to hazes, which can now be compared to exoplanet models and observations.

With Titan as an example, scientists found that hazes high above some transiting exoplanets might strictly limit what their spectra can reveal to planet transit observers information only from a planet’s upper atmosphere. On Titan, that corresponds to about 150–300 km (90–190 mi) above the moon’s surface, high above the bulk of its dense and complex atmosphere.

Titan’s hazes more strongly affect shorter wavelengths, or bluer, colors of light. Studies of exoplanet spectra have commonly assumed that hazes would affect all colors of light in similar ways. Studying sunsets through Titan’s hazes has revealed that this is not the case.

The team's technique applies equally well to similar observations taken from orbit around any world, not just Titan. This means that researchers could study the atmospheres of planets like Mars and Saturn in the context of exoplanet atmospheres as well. ##

Sunsets on Titan Reveal the Complexity of Hazy Exoplanets

Move Over Exoplanets, “Ewok” Exomoons May Harbor Life Too


April 28, 2014 – In the Star Wars universe, everyone’s favourite furry aliens, the Ewoks, famously lived on the “forest moon of Endor”. In scientific terms, the Ewok’s home world would be referred to as an exomoon, any moon that orbits an exoplanet – any planet that orbits a star other than our own sun.

Although more than 1,000 exoplanets have been discovered since the first one was found 19 years ago in 1995, only a handful of those are thought to be habitable, at least by “life as we know it.” ut new research shows that some exomoons could also prove to be habitable. Although we are yet to find our first exomoon, there should be many, even more than exoplanets, just as in our solar system, moons outnumber planets.

“Goldilocks zones”

Perhaps the most habitable planet found to date is one found recently, Kepler-186f, one of five exoplanets discovered by NASA’s Kepler telescope satellite, all orbiting a small, faint, red dwarf star, 500 light years away in the constellation of Cygnus. Kepler-186f is “Earth-sized “ and orbits its star in only 130 days at about the same distance as Mercury from our sun. Because this red dwarf is much dimmer than the Sun, Kepler-186f receives about a third of the energy that the Earth does. It lies at the outer edge of its star’s “habitable zone,” the hypothetical region of space surrounding a star in which liquid water may conceivably exist on the surface of an exoplanet.

In our own system, Venus lies too close to the Sun and is too hot; Mars too far from the Sun and too cold. But Earth lies within the critical “Goldilocks zone” where the temperatures are just right. But this is no guarantee that an exoplanet has water oceans. A planet’s climate is much more complicated than we can know with a simple calculation of its distance from its star. For example, we suspect that Mars probably had running water on its surface in the distant past, though it now is a frozen desert – in part because most of its original atmosphere has escaped into space. n the other hand, Earth was probably in a completely frozen “snowball” state about 650 million years ago.

Climate aside, not all exoplanets have a surface on which liquid water could exist. Many of the exoplanets found in the past 20 years are massive, Jupiter-sized gas planets – bigger planets are easier to find. Such a planet, while in its sun’s habitable zone is unlikely to have liquid water, much less a hard crust and is unlikely to become a habitat for life as we know it. With an outer atmosphere of gaseous and liquid hydrogen overlaying a metallic hydrogen envelope thousands of kilometres thick, any rocky surface would be that of a core under extreme atmospheric pressure.

But if a Jupiter-like planet orbits within its sun’s habitable zone, it could conceivably host habitable Mars or Earth-sized moons, like the Ewok’s home, or moon’s like Jupiter’s Europa, with a deep ocean under its ice crust, or like Saturn’s Enceladus, with an ocean underneath its coat of hydrocarbon ices. So Earth-like (in the sense that Europa is exomoons are likely to exist, and indeed may outnumber “Mars-like” and “Earth-like planets, because they are not restricted to temperate zones around a host star.

Finding the right temperature

Recent research focuses on the various factors that may make an exomoon more or less habitable. How the climate of an exomoon will be affected by tidal stresses which provide a source of internal heating for the exomoon as it is stretched and deformed by the gravitational pull of its planet, thus keeping a sub-crustal ocean liquid.

We are currently classifying theoretical exomoons into “habitable”, “hot”, “snowball,” or “transient” types. The “habitable” class have more than 10% of their surface at a temperature between the freezing and boiling points of water, with only a small fluctuation around the average temperature value.

Those in the “hot” class have average temperatures above 100°C (the boiling point of water) at all times, whereas those in the “snowball” class are permanently frozen – in both of these cases less than 10% of the surface is habitable.

Exomoons in the fourth “transient” class are on average habitable, but the amount of habitable surface area varies widely with time, making it difficult for life to survive. It is clear that exomoon climates are rather more complex than we had supposed.

But this is all in the realm of theory, as to date, no exomoons have been discovered. Various techniques have been suggested by which we may start finding them. One way is to study the effects that an exomoon will have on the exoplanet it is orbiting – their gravitational connection means there will be a to-and-fro tugging between them. This will cause variations in the times at which the planet transits in front of its star and in the durations of these transits, which small effects we are now able to measure.
Such timing variations will only be a few seconds at most, so very accurate measurements of the
transits must be made in order to reveal the presence of an exomoon. In principle, both the mass and
orbit of the exomoon may be calculated from the measurements.

It is only a matter of time before the first exomoon is discovered and the probability of finding one
in the habitable zone of a star is reasonably high. We may not find any Ewoks, but habitable exomoons
may indeed offer the best prospect for hosting alien life and could well outnumber Earth-like worlds.

Close Binary Suns Could Boost Odds of Habitable 'Exomoons'


[Editor; this article is so packed with information and insights that we could not “compact” it much more.]

Moons in close binary solar systems [such as the “Tatooine” system in the first Star Wars film (now
“4th” in the chronology) have a better chance of hosting life than those in single-star systems, new
research has shown.

Close binary stars revolving about one another within the orbit of their mutually closest planet,
(sharing all their planets, not just some, or none) dampen each other’s solar radiation and stellar winds,
thereby creating a more hospitable environment for life and increasing the habitable zone around such
solar systems, according to research presented at the 223rd American Astronomical Society meeting in
January.

Paul Mason, an astrophysicist at the University of Texas at El Paso, in an interview with
Astrobiology Magazine, presented the results of a study, which used data from NASA’s Kepler space
telescope to discover potentially habitable exoplanets in our region of the Milky Way galaxy.

Stretching the habitable zone

More than a thousand planets have been found outside of the solar system, as well as a host of
candidates waiting for follow-up observations. But no exo-moons have yet been confirmed. Mason and
others are performing theoretical calculations to determine which solar systems might be better for
hosting potentially habitable moons. But a close binary star system can dampen these effects, as the two
stars synchronize their spins, the same hemispheres always facing or always turned away.

Binary stars exist in a range of configurations. Some are widely separated, so that a planet in orbit
around one functions much like a planet around a single sun, while the companion is so distant that it
appears as point-like as any other star. A prime well-known example is the Alpha Centauri AB system.

[More than two decades ago, the editor dubbed them Ixion and Nephthele, after the King and
Queen of the Centaurs in ancient mythology.]

Other binary pairs may be extremely close together, synching together to keep each other rapidly
spinning for billions of years. Mason’s research focuses on pairs of stars that orbit each other between 10
and 60 Earth-days, with a planet in orbit around both suns. These are known as “circumbinary” systems,
popularly “Tatooine Systems.” The paired stars exert tidal forces on one another that cause a slowdown in
spin, weakening the radiation and stellar wind of the pair faster than they would suffer as single stars.
Fast-moving stellar winds can strip a moon or planet of its atmosphere, leaving it open to heavy radiation
bombardment that can interfere with the development of life.

At the same time, the combined light from the duo pushes the edge of the region where water can
exist, commonly termed the “habitable zone,” farther back than it would lie around a single star. Moving
the entire zone a greater distance from its sun further reduces the negative effects from the stars.

The habitable zone in a (close) binary system is a little bit farther away, simply because you have
the light from two stars rather than the light from one. This distance is important because, if a planet
orbits too close to its parent star, its moon can be stripped away completely. The closer a planet is to the
star, the smaller its gravitational sphere of influence. And the star will rip off the moon if it gets too close.
Pushing exomoons farther away also has ramifications for red dwarfs, the most populous stellar type in the galaxy. The habitable zone around these smaller, long-lived stars is so close to their parent star that stellar activity made many astronomers consider habitable planets around them unlikely to even exist, but recent research has increased the potential [www.astrobio.net/exclusive/3088/living-with-a-red-dwarf]. In a binary system, the pushed-back habitable zone would decrease many of the negative effects that limit habitability around these plentiful red dwarf stars.

If our sun had a companion star, the makeup of our solar system would change significantly. The water stripped from the atmosphere of Venus would likely still be present, making it potentially habitable. Earth itself could have been a very different environment, a wetter world orbiting a binary star.

**Twin suns**

When it comes to potentially habitable “exomoons”, sun-like stars are always better. “The ideal circumstance is solar twins,” Mason said. Simply adding a sun-like star to the mix improves the chances for life. Solar-type stars with companions work really well, better than our own solitary solar-type star.

In a circumbinary system, it is not the type of star that matters nearly as much as how often they orbit one another. As long as the pair of stars dance around between once every 10 and 60 Earth-days, they increase the chances of the habitability of their moons and planets. (However massive, giant stars burn through their fuel and die quickly, giving life little to no chance to evolve.)

If at least one of the two stars in a binary system is sun-like, it provides a very wide habitable zone with plenty of room for water, a situation that Mason finds most exciting. A wider habitable zone means a better chance of hosting planets capable of sustaining life, as well as exomoons that could support it. "There's plenty of room for several habitable planets and these may be places where many worlds in system could be habitable." Unfortunately, multiple planet systems make finding exomoons more challenging at the moment.

**The hunt for exomoons**

Astronomers hunt for distant moons essentially the same ways that they hunt for distant planets. They might watch for the planet and its moon to cross between their sun and the Earth. As a single planet crosses, it causes a dip in brightness; if a moon precedes or follows it, that dip is preceded or followed by a smaller dip as just the moon blocks the stellar light. They can also watch a planet for a small wobble as the moon gravitationally tugs its host ever-so-slightly. A moon might also slightly change how quickly a planet orbits its sun.

Kipping and his team have pared down the list of almost 5,000 planetary candidates detected by NASA’s Kepler spacecraft to approximately 250 bodies considered the best targets for hosting an exomoon. In the solar system, the only moons considered potentially habitable orbit gas giants. So originally, he hoped to target Jupiter-size and larger planets. Earth-sized moons could lay outside of the habitable zone of a star but still hold liquid water due to tidal heating from their planet. Such “Europid” moons would be minimally affected by their orbit around a binary star system instead of a single star.

But one of the most staggering discoveries from Kepler is that Jupiter-like planets are rare, Kipping said. Those are the planets easiest to find a moon around.

Kipping’s team has turned to the slightly less massive sub-Neptunes, which abound in Kepler’s field of view. Although moons around Earth-sized planets may not be habitable by themselves, they could have an enormous impact on their parent body, as has Earth’s moon. Born of a collision early in the life of the solar system, Earth’s moon is far larger by comparison to other moons in the solar system. The collision might have kicked off volcanism and plate tectonics on the early Earth, while the moon stabilizes the planet’s tilt and controls the tides, all four actions essential to the evolution of life.

"If we find Earth 2.0, one of the first things we’ll be asking is if it has a Moon 2.0." Because our moon is unique in the solar system, scientists don’t yet understand whether its formation was “a freak event” or something that’s very common. Detecting different kinds of moons in a variety of orbits will help scientists narrow down how unique the solar system and the Earth-moon system are.

Just as scientists have used Kepler to hunt for exoplanets, they have learned a lot about the variety of planetary systems in the galaxy. According to Kipping, circumbinary systems were once thought to be “the more exotic type” of binary systems. But Kepler revealed several cases, showing them to be fairly common. Though the mission goal is to detect planets, Kepler has become an important tool when it comes to looking for moons outside of our solar system.

While NASA’s upcoming James Webb Space Telescope, to be launched in October 2018, will be ideal for follow-up observations, it will be in too high of a demand by the astronomical community to stare at a patch of sky for years on end the way Kepler has done. If Kepler’s second run, K2, is funded, it will stare at a different region of the sky than the original mission, and thus will provide greater insight into planet populations by comparison of findings. Kepler is still probably the best resource for finding exomoons.
As to how long it might be before the first exomoon is confirmed around a distant planet, that depends on how common larger moons are. "If Nature builds big moons—Earth-sized moons—very frequently in the galaxy, then they're lurking in the Kepler data, we'll find them in a year or two."

If, however, most of the moons are small, like the ones in orbit around Neptune and Uranus, they may never be seen. If moons large enough to be detected exist, the most habitable of them can be found in circumbinary systems. "Exomoons in binary systems may be more habitable than around single stars, maybe less common, but potentially more habitable."

---

**New Methane-Hunting Tool Could Boost Search for Alien Life**

http://www.space.com/26259-methane-detection-tool-alien-life.html

June 18, 2014 – Astronomers now have a powerful new tool to sniff out methane on alien planets. One of the building blocks of life, methane could be key to finding organisms beyond Earth. Using supercomputers, a team of scientists developed a new absorption spectrum for methane that's 2,000 times more comprehensive than previous models and can detect the molecule at temperatures up to 1,220° C (2,228 °F), higher than ever before.

The team believes their model could give scientists a more complete picture of the methane abundance on failed stars known as brown dwarfs and alien worlds. For example, the so-called "hot Jupiter" HD 189733b—a well-studied, blue-colored exoplanet 63 light-years away from Earth—might have 20 times more methane than previously believed.

**A boost in the search for alien life**

While methane can be produced by geologic sources, it also could be a sign of biologic activity. That means finding could be a potential sign of life. With current technology, scientists are often stuck looking at these hot worlds. Hot Jupiters are relatively easy to detect because they are huge planets with tight orbits and they block a large portion of light when they pass in front of their parent star. HD189733b, for example, causes a three percent drop in starlight.

Astronomers likely need better detection methods before they can analyze the atmosphere of alien planets in the habitable zone, where water and life could possible exist.

The European Space Agency's Exoplanet Characterization Observatory, or EChO, and NASA's James Webb Space Telescope, which might produce better data about a wider variety of alien worlds, allowing more research could be done to expand the model to include absorption lines for methane that's at even higher temperatures. His team is also working on expanding astronomers' spectral range for about 30 other molecules.

---

**A Star's Chemistry is the Key to its Planets' Ability to Support Life**


**Birth of planets from protoplanetary disks around newborn stars**

Born in a disc of gas and rubble, planets eventually come together as larger and larger pieces of dust and rock stick together. As far away as they may be, astronomers can nevertheless watch these planets as they form. The molecules that are in those discs will make up the molecules in planetary atmospheres.

**Seeking high definition observations**

Molecules in protoplanetary discs emit their light in the millimeter and sub–millimeter frequencies of light, which are between the observation ranges of radio telescopes and infrared telescopes. Until recently, however, there have been few observatories devoted to this particular band of light with the necessary capabilities to see complex molecules.

With single–dish submillimeter telescopes, astronomers could not get the high spatial resolution and sensitivity that they need to see more complex molecules. This changed in 2013, however, when the Atacama Large Millimetre Array (ALMA) in Chile lighted up for the first time. The observatory will eventually include 66 antennas located at 5,000 meters altitude, which puts it above much of the section of the atmosphere that blocks millimeter light from arriving at the surface. ALMA will give us orders of magnitude (of improvement) in sensitivity — but although her team has submitted a proposal to examine molecules using the giant array, the popularity of the telescope (which brings many competing proposals) means she is not sure if they will succeed.

Which complex molecules are present in protoplanetary discs, and would ALMA be able to see them? Complex molecules are not only potential precursors of life, but the ices in which they are thought...
to form also acts as a coagulant for dust grains to stick together and form planets. Molecules are visible from afar because their rotation produces distinctive spectra, line emissions that can be seen from Earth.

Formaldehyde, a molecule with four atoms, has been detected in previous observations of protoplanetary discs. However, astronomers would like to find a more complex molecule like methanol, a derivative of methane, which on Earth is naturally produced by bacteria. In space, methanol is formed slightly differently: it is a derivative of carbon monoxide.

Methanol hasn't been seen yet in protoplanetary discs. The more complex a molecule is, the less bright its spectrum appears in telescopes, making it harder to spot. The ALMA telescope should be up to the task of spotting methanol, and that could lead to the discovery of even more complex molecules, containing both oxygen and nitrogen.

The next research step is to find glycine — the simplest amino acid and a building block for proteins — in protoplanetary discs. Glycine is a prebiotic building block of life. Could ALMA detect glycine?

If not, the Square Kilometer Array, under construction in both Australia and South Africa, will pick up a set of complex molecules with longer wavelengths and lower frequencies than ALMA.

---

**Continents May Be Key Feature of 'Super–Earth' Alien Planets**


Huge Earth–like planets that have both continents and oceans may be better at harboring extraterrestrial life than ‘water–only’ worlds. A new study gives hope for the possibility that many super–Earth planets orbiting distant stars have exposed continents rather than just water–covered surfaces.

Super–Earths are likely to have more stable climates than water worlds, and therefore larger habitable zones where alien life could thrive. In the new study, researchers used the Earth as a starting point for modeling how super–Earths might store their water on the surface and deep underground within the mantle. The work is detailed in a paper titled *“Water Cycling Between Ocean and Mantle: Super–Earths Need Not Be Waterworlds”* published in the January issue of The Astrophysical Journal.

Researchers typically expect super–Earths to exist as water worlds because their strong surface gravity creates relatively flattened surface geography and deep oceans. But the new study found that super–Earths with active tectonics can have exposed continents if their water is less than 0.2 percent of the total planetary mass.

"A planet could be 10 times wetter than Earth and still have exposed continents," said Nicolas Cowan, a planetary scientist at Northwestern University and co–author on the new paper. "That's important for what the planet looks like and how it ages."

The model uses Earth as a starting point in defining how a planet's water distribution could end up balanced in a steady state between the surface oceans and the mantle, which allows the researchers to calculate whether a super–Earth is likely to be a water world or not.

The movement of tectonic plates on Earth transfers water continuously between the surface ocean and the mantle. Ocean water enters the mantle as part of deep–sea rocks when one tectonic plate slides under another and goes down into the mantle.

"Earth is the only known planet with plate tectonics, a deep water cycle, etc., so it's a good place to start," say the authors. Water in the mantle can re–enter the ocean when volcanic activity splits the planet's crust at mid–ocean ridges. The loss of the crust causes a drop in pressure that leads the underlying mantle rock to melt and lose volatiles such as water. An additional twist is that super–Earths with their stronger gravity could have greater seafloor pressure that suppresses the mantle’s loss of water, so that more of the planet’s overall water remains in the mantle.

There are other uncertainties. One is the amount of water hidden deep within Earth's own mantle; The authors cite estimates of one to two oceans' worth of water. Another factor is whether or not super–Earths have tectonic processes. If the assumptions about either factor are wrong, that would change the model's calculation of the "water world boundary," which represents the mathematical model's dividing point between water–worlds and worlds with dry continents.

The authors tried to compensate for the unknowns by drawing conservative conclusions with the results from their mathematical model. But even those conclusions suggest that super–Earths need not be water worlds. "No matter how you cut it, though, the water world boundary is unlikely to be as damning as previously thought."

The debate over super–Earths will continue until space missions begin collecting hard data on how much water exists on such planets. A space telescope with an interior coronagraph or exterior starshade...
could block the blinding light of distant stars to get a peek at orbiting planets. But no active space telescopes can currently do the necessary work of mapping the surface of super-Earths.

"At the very least, you'd need a space telescope with a mirror a few meters wide, coupled to a starshade tens of thousands of kilometers away - not the next priority." But there is one space telescope that could fill the bill – NASA's Wide-Field Infrared Survey Telescope (WFIRST) — a planned 2.4-meter telescope with an instrument for imaging exoplanets. The $1.6 billion mission remains up in the air until NASA can squeeze it into the budget, but WFIRST could get off the ground by the mid-2020s or 2030s. If so, that would bring researchers one step closer to understanding whether super-Earths truly work like our own world. ##

**Habitable Exoplanets may be Bad News for Humanity (Op-Ed)**

www.space.com/25642-habitable-exoplanets-are-bad-news-for-humanity-op-ed.html
http://www.space.com/25531-new-earth-size-planet-could-have-water-video.html

April 26, 2014 – Scientists have announced the discovery of Kepler-186f, a planet 492 light years away in the Cygnus constellation. Kepler-186f is special because it marks the first planet almost exactly the same size as Earth orbiting in the “habitable zone” – the distance from a star in which we might expect liquid water, and perhaps life.

**“The Great Filter”**

What did not make the news, however, is that this discovery also slightly increases how much credence we give to the possibility of near-term human extinction, because of a concept known as “the Great Filter,” an argument that attempts to resolve the Fermi Paradox

Why have we not found aliens, despite the existence of hundreds of billions of solar systems in our galactic neighbourhood in which life might evolve? As the namesake physicist Enrico Fermi noted, it seems rather extraordinary that not a single extraterrestrial signal or engineering project has been detected (UFO conspiracy theorists notwithstanding).

**This apparent absence of thriving extraterrestrial civilisations** suggests that “at least one of the steps from humble planet to interstellar civilisation is exceedingly unlikely.”

The absence could be caused because

- Either intelligent life is extremely rare
- Or intelligent life has a tendency to go extinct.

This bottleneck for the emergence of alien civilisations from any one of the many billions of planets is referred to as the Great Filter.

**Are we alone? What exactly is causing this bottleneck?**

- A paucity of Earth-like planets?
- A paucity of self-replicating molecules?
- An improbable jump from simple prokaryotic life (cells without specialised parts) to more complex eukaryotic life? – after all, this transition took well over a billion years on Earth.

**The evolution of complex life requires an exceedingly large number of perfect conditions.**

In addition to Earth being in the habitable zone of the sun,

- Our star must be far enough away from the galactic centre to avoid destructive radiation,
- Our gas giants must be massive enough to sweep asteroids from Earth's trajectory,
- Our unusually large moon stabilises Earth's axial tilt that gives us different seasons.

These are just a few prerequisites for complex life. The emergence of symbolic language, tools and intelligence could require other such "perfect conditions" as well.

**Or is the filter ahead of us?**

While emergence of intelligent life could be rare, the silence could also be the result of intelligent life emerging frequently but subsequently failing to survive for long (self-chosen blindness to civilization-caused environmental degradation, for example).

Might every sufficiently advanced civilisation stumble across a suicidal technology or unsustainable trajectory? We know that a Great Filter prevents the emergence of prosperous interstellar civilisations, but we don’t know whether or not it lies in humanity’s past or awaits us in the future.
For 200,000 years humanity has survived supervolcanoes, asteroid impacts, and naturally occurring pandemics. But our track record of survival is limited to just a few decades in the presence of nuclear weaponry. And we have no track record at all of surviving many of the radically novel technologies that are yet to be developed. Advances in biotechnology could be potentially catastrophic.

Let’s hope Kepler-186f is barren

When the Fermi Paradox was initially proposed, it was thought that planets themselves were rare. Since then, however, the tools of astronomy have revealed the existence of hundreds of exoplanets. This is probably just the tip of the iceberg.

But each new discovery of an Earth–like planet in the habitable zone, such as Kepler-186f, makes it less plausible that there are simply no planets aside from Earth that might support life. The Great Filter is thus more likely to be lurking in the path between habitable planet and flourishing civilisation.

The more common are planets with flourishing life, the worse it would seem are the future prospects for humanity. For that fact would push back the Great Filter’s position further into the technological stages of a civilisation’s development. We might then expect that catastrophe awaits both our extraterrestrial companions and ourselves.

The silence of the night sky is golden ... in the search for extraterrestrial life, no news is good news. It promises a potentially great future for humanity.

EDITOR: The concept of “The Great Filter” rests entirely on the belief that intelligent civilizations would broadcast their existence to any others “out there.” But that belief may be totally false. Why?

There are two reasons we are not hearing from other advanced civilizations in our galaxy and beyond, other than there “not being any.”

• It is cheap to “listen,” but many orders of magnitude more expensive to “speak” Thus everyone is “listening” and no one is “speaking.” To guarantee being heard, a message must be continually repeated for thousands, if not millions of years at significant strength in a form that resists degradation – this is what we might call a millennia-long “Cathedral building project,” something that “Messianic” civilizations might do. On the other hand, our “listening” exercises have been very brief, making it very probable that we would miss any messages. Listening is cheap.

• The “Prime Directive” – In the epic Star Trek film series, our civilization, and presumably all others with any sense of moral integrity observed the “Prime Directive” to “not interfere with the progress of less advanced cultures.” Fiction or not, any civilization mature enough to be thoughtful and respectful of less advanced but still technical civilizations, will refrain from broadcasting their own “superior” civilization. While most “thinking civilizations” are likely to observe such a principle under whatever name, there may be misguided “messianic civilizations” that believe they are pre-ordained to spread their “gospel” to the rest of the universe. Even so, it remains that it is so very easy to listen but so very difficult and expensive to broadcast long enough, far enough, without message degradation.

• Yet the Cosmos must be filled with “virtual transmissions” – thinking, spiritually respective persons throughout space and time looking up at their own star-filled heavens, and saying silently, to all with enough spiritual sensitivity to hear nonetheless, “Greetings, fellow creatures! We share the same creatural conditions and obstacles. Isn’t it wonderful to be alive. Live long and prosper!” And without any kind of physical signal or communications medium, in our inner souls we hear, and respond “May you live long and prosper too!”

• And that is “the Great Filter” – the universe may be filled throughout time and space with civilizations, some of them long lived (assuming that their own misnamed “conservatives” do not succeed in getting the rest of their fellow citizens to pooh pooh warning signals of environmental degradation.)

If there is a “Great Filter,” it may be mutual respect.

Are We Alone in our Galaxy? How soon might we find Intelligent Alien Life?
VIDEO: http://www.space.com/9788-search-intelligent-life-4-key-questions.html

Video Tour of Alien Planets Shows How Time Flies on Strange New Worlds
NASA's Spitzer and WISE Telescopes Find a Close, Cold Neighbor of the Sun


April 25, 2014 RELEASE 14-116 – NASA's Wide-field Infrared Survey Explorer (WISE) and Spitzer Space Telescope have discovered what appears to be the coldest "brown dwarf" known -- a dim, star-like body that, surprisingly, is as frigid as our North or South Pole. Images from these space telescopes also pinpointed the object's distance to 7.2 light-years away, earning it the title for fourth closest system to our sun. The closest system is Alpha Centauri, at 4.3 light-years away. Given its extreme temperature, it should tell us a lot about the atmospheres of planets, which often have similarly cold temperatures.

Brown dwarfs begin as stars, collapsing balls of gas, but lack enough mass to burn nuclear fuel and radiate starlight. The newfound coldest brown dwarf is named WISE J085510.83-071442.5. Its temperature is between -48 to -13 °C (~-54 to 9 °F). Previous record holders for coldest brown dwarfs, also found by WISE and Spitzer, were about room temperature c. 20°C (c. 68°F).

WISE could spot the rare object because it surveyed the entire sky twice in infrared light, observing some areas up to three times. Cool objects like brown dwarfs can be invisible when viewed by visible-light telescopes, but their feeble thermal glow stands out in infrared light.

In addition, the closer a body, the more it appears to move in images taken months apart. This object appeared to move really fast in the WISE data. After the fast motion of WISE J085510.83–071442.5 was noticed in March, 2013, more time was spent analyzing additional images taken with Spitzer and the Gemini South telescope on Cerro Pachon in Chile. Spitzer's infrared observations helped determine the frosty temperature of the brown dwarf. Combined detections from WISE and Spitzer, from different positions around the sun, enabled the measurement of its distance through the parallax effect.

After many decades of studying the sky, we do not have a complete inventory of the sun's nearest neighbors. This exciting new result demonstrates the power of re-exploring the universe using new tools.

WISE J085510.83–071442.5 has some 3 to 10 times the mass of Jupiter. With such a low mass, it could be a rogue gas giant similar to Jupiter that was ejected from its star system. But scientists estimate it is probably a brown dwarf rather than a planet since brown dwarfs are known to be fairly common. If so, it is one of the least massive brown dwarfs known.

In March of 2013, analysis of the images from WISE uncovered a pair of much warmer brown dwarfs at a distance of 6.5 light years, 0.7 light years closer, making that system the third closest to the sun.

The search for rapidly moving bodies also demonstrated that the outer solar system probably does not contain a large, undiscovered planet, often referred to as "Planet X" or "Nemesis."

##

Could Alien Life Cope with a Hotter, Brighter Star?


BACKGROUND INFORMATION

The amount of matter stars contain determines not only their surface temperature, but their size and lifetime as well. More massive stars generate stronger gravity; stronger gravity creates higher inside temperatures and pressures, therefore making the star’s nuclear fusion furnace much more efficient. Atomic nuclei fuse at higher rates and release more energy in compressed conditions. As a result, more massive stars put out more light and heat as they burn their nuclear fuel at a faster pace than cooler, less massive stars – but such stars reach the end of their lives on the mainstream sooner than will our Sun with billions of years ahead.
F-type main sequence stars have a mass about 10 to 60 percent greater than the Sun’s. That added mass gives the star a surface temperature ranging from about 5,800 to 6,900 °C (10,500 to 12,500 °F) for comparison, our Sun’s surface is a bit shy of 5,500 °C (10,000 °F).

A star’s hotness determines their color and thus their classification according to the standard Morgan–Keenan system: from the bluest and hottest stars to the reddest and coolest, as follows: O, B, A, F, G, K, M.

O and B types blaze at too high a temperature and live far too short a time (mere millions to hundreds of millions of years) for life to stand a chance, and the third type is often considered irrelevant as well. Life took an estimated half a billion years to establish itself on Earth, and another two to three billion years to develop multicellular complexity. (Earth and the Sun are presently about 4.6 billion years old.) F-type main–sequence stars are expected to remain stable for about 2 to 4 billion years as detailed models suggest. (Our Sun should have a correspondingly stable lifetime of approximately 10 billion years.)

The authors of this article believe that “The lifetimes of F-type stars on the main–sequence appear to be sufficiently long for life having a chance to start and to flourish.” We are much more confident about life having a chance to start, but less so about life having a chance to flourish [in the rise of an intelligent species.]

The stars in the night sky shine in various colors— blues, whites, yellows, and reds. Every star has a different mass, the basic characteristic that determines its size, lifespan, light output and temperature (temperature determining the color hue.)

Yellow–white stars like our Sun, and cooler ones

The only star type we know with certainty that has a planet which has seen life arise to its climax in an intelligent species is a toasty, yellow–whitish one, our Sun. Now 4.5 billion years old, the Sun could last as many more years more as it is. Astrobilologists are quite convinced that life can also develop on planets orbiting smaller, cooler stars, with even longer stable lifetimes.

What about hotter, “whiter” stars

A new paper, accepted for publication in the International Journal of Astrobiology, examines some of the fundamentals for life arising around a class of slightly heftier, hotter stars known as F-type main–sequence stars. (Stars in the main–sequence are in “full bloom,” so to speak, and like our Sun, fuse hydrogen into helium in their cores.)

Procyon, a bright white star and the brightest star in the constellation Canis Minor, is a well–known F-type main–sequence star. These bigger cousins to the Sun differ from our home star in many important ways when it comes to astrobiology.

The higher levels of ultraviolet (UV) radiation cranked out by F-type stars could hinder the development of alien life. UV rays can alter or destroy the molecules, such as DNA, that are deemed necessary for carbon–based biochemistry.

And they live shorter lives than slower–burning stars like the Sun and dimmer stars. This variable is important because life, as we understand it, life needs a lot of time to get going and to eventually evolve complexity. Brighter stars might not live long enough to see life evolve on planets in their habitable zone but will their sun life long enough on the main sequence to give rise to an intelligent species? The only example we have to go by is our own Sun, and it has taken life on Earth 4.6 billion years to blossom in an intelligent species. That could be shorter or longer than an average we can only guess about.

But the more massive a star type is, the rarer it is. So there are far fewer such stars brighter than our own Sun – and with shorter their lifetimes on the “main sequence” of stable light output. If the 4.6 billion years it took for humanity to evolve on Earth is typical for G type stars, then many F type stars may not live long enough on the main sequence to see intelligent life arise and flourish.

Most of the stars visible to the naked eye are intrinsically brighter than the Sun. So the heavens we see are a guide to how many stars of what type are out there. Our Sun and its life–bearing planet Earth, are the only example

F type “whites” are likely the brightest and hottest main–sequence stars that could plausibly allow life to form. Hotter stars go nova or supernova long before climax had time to evolve on any planet they may have. So most of the stars we see with the naked eye, whites and blues and giant reds will go nova long before life could evolve very far on any planets they may have.

F type “suns” – Too harsh a glare?

The light from F-type stars, however, is more intense than that from our Sun. Hotter stars churn out more higher–energy forms of light, such as UV, than their less massive cousins, which can make a profound difference when considering habitability.
The study by Cuntz and colleagues considered F-type stars in the mass range of 1.2 to 1.5 times that of the Sun. DNA molecules under the glare of an F-type star would suffer 2.5 to 7.1 more damage from UV light compared to that inflicted by the Sun. Life-friendly hydrocarbon molecules would suffer serious degradation, potentially enough to wreck the delicate chemistry that underlies biology.

**Shaded, safer place on planets around F-type yellow–white suns.**

Game over for life? Not quite. We need to take into account the extent to which shielding of some sort—say, an atmosphere or submersion in water—could block some harmful UV rays. Most biologists think life arose on primordial Earth in an aqueous environment anyhow and perhaps well beyond the reach of UV rays at hydrothermal vents on ancient ocean floors. Similarly, by living underwater, or underground, Cuntz said, primitive single–celled creatures could survive on a world awash in heavy UV light from an F-type star.

**Development of multi–cellular, complex life on a planet around an F-type star, though, would require the sort of UV protection afforded by an ozone layer.** Earth has just such a layer, high up in the atmosphere, of ozone molecules composed of three oxygen atoms. The layer absorbs nearly all of the highest–energy and thus most dangerous kind of UV rays, dubbed UVC. These rays would otherwise penetrate to our planet's surface and could kill off exposed life forms. Some less–energetic UVA and UVB rays still reach the ground, where they damage our skin, causing sunburns and skin cancers.

In a seeming paradox, Earth's protective ozone layer is actually thought to have arisen thanks to life. Early in our planet's history, photosynthetic life—partially shielded from UV rays by water—loaded the atmosphere up with the oxygen gas that then reacted with sunlight to produce ozone. Accordingly, simple life paved the way for more complex life as an ozone layer took hold; such a stepwise evolutionary process could transpire on an F-type star's planetary bodies.

Thus extra UV light exposure may not be wholly bad, although it can damage biomolecules, UV could also give burgeoning life a handy spark, providing a source of energy. It could also be helpful to jumpstart the origin of life by providing a highly reactive biochemical environment.

UV may be both a friend and a foe to the principal possibility of life. At the present stage of life on Earth, the lack of an ozone layer would be truly harmful to most types of surface life. On the other hand, in regard to life's origin and early stages of evolution, a notable UV intensity could facilitate the onset of life by triggering relevant early–stage biochemical reactions."

**To the point**

More, but not too much more, UV exposure could even provide a biological bonus by causing DNA to mutate more rapidly—the very essence of evolution, especially during its early stages. If so, planets of F type stars might see complex life arise faster than it has on Earth. Add to that the “habitable zone” around such warmer stars is larger and could support more life bearing planets than just one..

The paper cites prior work gauging a relatively hot F0 star as possessing a habitable zone extending from about 2.0 AU to 3.7 AU—a band more than twice that of the Sun's, reckoned span of 0.8 AU to 1.5 AU. The habitable zone for a comparatively cool F–type star, an F8, meanwhile, extends between 1.1 and 2.2 AU. It follows that exoplanets placed at the outer edges of their respective F–type star's habitable zones, and orbiting lower–end F–type stars rather than those roasters bordering on the A–type star category, would receive less UV light.

Life should stand a reasonably good chance of developing in the cooler, less–severe–UV realms about F–type stars. The cons of F–type main sequence stars—more UV, shorter stellar lifetimes—do not eliminate them from astrobiological contention along with their smaller cousins, G-type, K-type and M–type stars. "When it comes to evaluating F–type star planetary habitability, it is necessary to keep an open mind on the various important and intertwined topics of exobiology, and to promote future research."

Editor: In Moon Miners' Manifesto #45 Welcome–Mat Worlds, written way back in May, 1991, I suggested that many F stars might reach the end of their lives on the main sequence before there was enough time for life to climax in the rise of a sapient species like ourselves - that is “if” the amount of time it took mankind to arise in our system is typical (we have only our own example to go by.)

We concluded that humans could safely head for such star systems without worrying about intruding on a system where intelligent life might already exist or be well on the road to evolving.

But, given the deeper analysis in this new paper, we may well see some exceptions.

Readers can see this article, "Welcome Mat Worlds," in the following free download MMM Theme Issue.

Want to Find Alien Life? It Will Take A Lot of Luck

COLORADO SPRINGS, Colo. — Humanity will have the tools to detect alien life in the next two decades, but whether scientists can actually find life in another solar system depends a lot on luck, according to a panel of experts.

While the James Webb Space Telescope, expected to launch in 2018, will have the ability to search for the chemical signatures of life in the atmospheres of alien worlds, it doesn't necessarily guarantee that scientists will find extraterrestrial life somewhere in the universe. No one is sure how life begins or how ubiquitous it is, making it very difficult to pinpoint when and where to find it.

Scientists can stack the odds in their favor, however, by building new, bigger space telescopes to allow us to look at more stars, making the odds better that exoplanet hunters will find signs of life — like plant-produced oxygen or potentially methane — within an atmosphere. Life metabolizes and generates gasses, so that's what we're looking for.

A mission still in the early stages of development could also help scientists investigate alien worlds even without the use of a large telescope. Called a “starshade,” the huge sunflower–shaped craft would block light from a star to allow a well–positioned space telescope to look at the atmospheres of rocky planets orbiting sun–like stars, a historically difficult feat.

Life could also be lurking in our solar system. NASA has started investigating a possible mission to Jupiter's icy moon Europa to be launched sometime in the 2020s.*  Microbial life could survive in the ocean beneath the moon's ice shell. Finding life under Europa's icy shell could also impact the hunt for living things outside of the solar system. If we see just one case, we almost know that it's everywhere. ##


Astronomical Forensics Uncover Planetary Disks in NASA's Hubble Archive

April 24, 2014 – Astronomers using NASA's Hubble Space Telescope have applied a new image processing technique to obtain near-infrared scattered light photos of five disks observed around young stars. These disks are telltale evidence for newly formed planets. If astronomers initially miss something in their review of data, they can make new discoveries by revisiting earlier data with new image processing techniques, thanks to the wealth of information stored in the Hubble data archive. This is what Rémi Soummer, of the Space Telescope Science Institute (STScI) in Baltimore, Md., and his team recently did while on a hunt for hidden Hubble treasures.

The stars in question initially were targeted with Hubble's Near Infrared Camera and Multi–Object Spectrometer (NICMOS) based on unusual heat signatures obtained from NASA's Spitzer Space Telescope and the Infrared Astronomical Satellite that flew in 1983. The previous data provided interesting clues that dusty disks could exist around these stars. Small dust particles in the disks might scatter light and therefore make the disks visible. But when Hubble first viewed the stars between 1999 and 2006, no disks were detected in the NICMOS pictures.

Recently, with improvements in image processing, including algorithms used for face–recognition software, the archived images. This time, they could unequivocally see the debris disks and their shapes were unmistakable.
The NICMOS instrument, which began collecting data in 1997, has been so cutting-edge that ground-based technology only now is beginning to match its power. Because Hubble has been in operation for almost 24 years, it provides a long baseline of high-quality archival observations. With such new technologies in image processing, we can go back to the archive and conduct research more precisely than previously possible with NICMOS data.

These findings increase the number of debris disks seen in scattered light from 18 to 23. By significantly adding to the known population and by showing the variety of shapes in these new disks, Hubble can help astronomers learn more about how planetary systems form and evolve.

The dust in the disks is likely produced by collisions between small planetary bodies like asteroids. The tiniest particles are constantly blown outward by radiation pressure from the star. They must be replenished continuously though more collisions. This “game” was common in the solar system 4.5 billion years ago. Earth’s Moon and the satellite system around Pluto are collisional byproducts.

One star that is particularly interesting is HD 141943, “an exact twin of our sun during the epoch of terrestrial planet formation in our own solar system.” Hubble found the star exhibits an asymmetrical, edge-on disk. This asymmetry could be evidence the disk is being gravitationally sculpted by the tug of one or more unseen planets. ##

---

**Pulsing Stars Help Map Milky Way’s Outer Reaches**

May 14, 2014 – New observations of five young Cepheid variable stars reveal a strange thickening in farflung regions of the Milky Way galaxy. These stars are positioned above and below the plane of the galaxy’s disk. That position, combined with the stars’ young age, indicates a warp to the arm that was previously suggested by observations of dust, but had not been shown by the presence of stars.

A team of astronomers utilized two telescopes at the South African Astronomical Observatory (SAAO) to determine that the five Cepheid variables lie on the far side of the bulge of material in the heart of the Milky Way, above and below the galactic plane. Of the original 32 stars studied, the team classified five as true Cepheid variables and established their distances, as well as how quickly they travel.

Although the stars lie in a stream associated with the Sagittarius dwarf galaxy, the astronomers quickly determined that the objects were traveling too slowly to be a part of that branch and that the objects could not be part of the Milky Way’s bulge, as they lie too far from the galactic center.

The age of the variable stars ruled out the idea that they are isolated outliers. At only about 150 million years old, the Cepheids are young stars, while single stars tend to be older. Instead, the variable stars form part of a disk that thickens as it extends out of the galaxy.

Previous studies of hydrogen gas suggested that the disk of our Milky Way Galaxy flares outward rather than levels off, but no previous observations of stars could confirm the idea. But the Cepheids lie at exactly the distance predicted for this increase in disk thickness, This implies that the flare consists not only of gas but also of stars — a characteristic that was not previously known.

**Dark matter warps the disk?**

The cause behind the flaring remains uncertain, but one possible explanation is the presence of a halo of dark matter surrounding galaxies like the Milky Way. The diffuse matter in the outer disk is more strongly affected by this mysterious stuff, which neither absorbs nor emits light, but makes up about 80 percent of the material universe.

Such warping in other galaxies could theoretically help in measuring their dark matter distribution. However, the diffuse gas is difficult to track. By studying stars such as the Cepheid variables, astronomers can nail down a more detailed understanding of the shape of the Milky Way. ##
Weird Loner Exoplanet Orbits Far From Its Star


An exoplanet that orbits its star at 2,000 times the Sun–Earth distance — (66 times Neptune’s distance) and taking 80,000 Earth years to complete one orbit — the most extreme orbit found to date.

This exo–world was found during an observing campaign seeking out new worlds around a group of young stars. GU Psc, a star roughly a third of the size of our sun, was recently identified as a member of the AB Doradus group and became a ripe target for this exoplanetary search.

AB Doradus stars are around 100 million years old and attractive targets for exoplanetary searches through direct means. As the stars are so young, any planets in tow will still be hot after recently forming from stellar material. These worlds are radiating energy into space, illuminated in infrared light. ##

New Exoplanet Hunter Directly Images Alien Worlds


January 7, 2014 – A new “car–sized” instrument, the Gemini Planet Imager (GPI) attached to the 8–meter Gemini South telescope in Chile, has opened its infrared eye for the first time, taking snapshots of a nearby planet orbiting another star and a ring of proto–planetary stellar dust. In development since 2003, the GPI is capable of not only resolving the dim light from an exoplanet orbiting close to its parent star; it can also analyze the planet’s atmospheric composition and temperature.

Most ground–based exoplanet surveys watch for a star’s “wobble” to betray the gravitational presence of massive exoplanets in orbit -- the “radial velocity technique.” Another powerful technique for discovering smaller exoplanets in tight orbits around their star is employed by NASA’s Kepler space telescope. As an exoplanet passes in front of its host star, a small dip in brightness can be detected by Kepler’s sensitive optics – this is known as a “transit.”

Other methods are possible (such as microlensing. But the “Holy Grail” for astronomers is to use a powerful telescope to directly image star systems, picking out tiny dots of light in orbit. This feat has been achieved a handful of times (most notably the 2008 Hubble and Keck/Gemini announcements of directly imaging exoplanets around the stars Fomalhaut and HR 8799) its wholesale use as an effective exoplanet–hunting tool has been limited by technology, a limit that the GPI has now dramatically lifted.

Through the ingenious combination of adaptive optics -- a laser system used on some observatories that can actively counteract the blurring effects of turbulence in the Earth’s atmosphere -- and an active obscuring coronagraph perfectly covering the star (to counteract the glaring effect of the starlight), GPI has the power to distinguish star from exoplanet to unparalleled precision.

“Most planets that we know about to date are only known because of indirect methods that tell us a planet is there, a bit about its orbit and mass, but not much else,” said Bruce Macintosh of the Lawrence Livermore National Laboratory, who led the team that developed GPI. “With GPI we directly image planets around stars -- it’s a bit like being able to dissect the system and really dive into the planet’s atmospheric makeup and characteristics.” ##
First 'Sibling' of Sun Found

http://www.space.com/25881-sun-sister-star-found-hd162826.html

May 15, 2014 – Astronomers have likely discovered the first sibling of the Sun, a star born from the same cloud of gas and dust as the one that lights Earth's days.

Finding more solar siblings could help shed light on how the solar system came to harbor life, researchers said, adding that life may even teem on the planets circling such sister stars. Stars are typically born alongside many siblings within giant clouds of gas and dust known as stellar nurseries. The sun was probably born in a cluster containing 1,000 to 10,000 stars.

At first, sibling stars remain near each other, as we see in the “Pleiades” cluster or Seven Sisters, dominated by hot, bright stars that formed within the last 100 million years. The stellar cluster the sun was born in broke up long ago, however, with its siblings now scattered across the Milky Way.

Finding solar siblings

To recognize a star as a solar sibling, researchers need to detect at least two identifying features: similar chemical compositions and orbits that suggest they might share the same birthplace as the sun. Now they have discovered a star called HD 162826, located 110 light-years away in the constellation Hercules. This star can be seen with low-power binoculars, near the bright star Vega.

The team examined the spectrum of 30 possible solar siblings previously identified by several groups around the world, looking for their chemical makeup. Light comes in a wide variety of wavelengths, some visible and many invisible. The wavelengths of light that an element gives off can act like a fingerprint, revealing the identity of the material in question.

The chemical compositions of the sun and its siblings are similar because the stellar nursery in which they formed was seasoned by material given off by nearby stars, and potentially by remnants of stellar explosions known as supernovas. The ratio of abundances of a few chemical elements are key parts of this chemical fingerprint — barium and yttrium, for example.

After this analysis, they were left with two potential candidates. They next modeled the orbits of these stars around the center of our galaxy. One of these candidates, HD 162826, may have shared the stellar nursery the sun was born in about 4.6 billion years ago.

The researchers expect the number of these sibling stars that they can find to be very low. Although HD 162826 is a sibling of the sun, it is not a solar twin. Rather, this star is 15 percent more massive than the sun. ##

Editor: Back in November 1998, in MMM #120, we published an article suggesting a search for “The Heliades” – siblings of the Sun born in the same cluster. (The Greek word for the Sun is Helios)
You can read this article in the MMM Starbound Theme issue at:


Also relevant is a more recent article in MMM #247, “Our Planets may be the offspring of a tryst between ProtoSun and another protostar”– (The “isotopic DNA” of the Sun and its Planets do not match!)

You can read this article in the same Starbound theme issue noted above.
June 3, 2014 – Astronomers have discovered the oldest known alien world possibly capable of supporting life, not far from Earth. Kapteyn b, a mere 13 light-years away, is about 11.5 billion years old, 7 billion years older than Earth, and just 2 billion years or so younger than the universe itself.

What kind of life could have evolved on those planets over such a long time?

Kapteyn b and its newly discovered sister world, Kapteyn c, both orbit a nearby red dwarf known as Kapteyn's Star. Kapteyn b is a "super-Earth" about five times as massive as Earth, is thought to be potentially habitable; but the larger Kapteyn c is likely too cold.

Astronomers spotted both planets by noting the tiny wobbles their gravitational tugs induced in the motion of Kapteyn's Star. These tugs caused shifts in the star's light, which were first detected using the HARPS spectrometer at the European Southern Observatory's La Silla Observatory in Chile. Further observations by two other spectrometers — HIRES at the Keck Observatory in Hawaii and the PFS instrument at Chile's Magellan II Telescope — backed up the finds.

Kapteyn's Star is Just a third as massive as the sun but is so close to Earth that it is visible in amateur telescopes in the southern constellation of Pictor. Kapteyn b lies in the star's habitable zone, the range of distances that could support liquid water on its surface — and thus, perhaps, life as we know it. The planet completes one orbit every 48 days. Colder Kapteyn c is farther out, orbits once every 121 days.

The Kapteyn system has a strange history — it appears to have originally belonged to a dwarf galaxy that our own Milky Way absorbed and disrupted, judging from the system's speedy elliptical orbit in the galactic "halo" — the region surrounding the Milky Way's familiar spiral-armed disk. The remnant of this gobbled-up dwarf galaxy is likely Omega Centauri, a globular cluster about 16,000 light-years away that contains many thousands of stars around 11.5 billion years old,

The new discovery suggests that many potentially habitable worlds will be found in the next years around nearby stars by ground-based and space-based observatories such as ESA's PLATO mission. But until we have detected a larger number of them, the properties and possible habitability of the near–most planetary systems will remain mysterious."  ##

### Gliese 832c, just 16 light-years away, may be capable of supporting life

June 25, 2014 – A newfound planet, just 16 light years away, might be able to support life.

Astronomers have discovered an exoplanet, in the star Gliese 832's "habitable zone" — the just-right range of distances that could allow liquid water to exist on a world's surface. Gliese 832c is a "super-Earth" at least five times as massive as our planet, and it zips around its host star every 36 days. But that host star is a red dwarf that's much dimmer and cooler than our sun, so Gliese 832c receives about as much stellar energy as Earth does, despite orbiting much closer to its parent, researchers said.

The Earth Similarity Index (ESI) of Gliese 832c (0.81) is comparable to Gliese 667Cc (ESI = 0.84) and Kepler–62e (ESI = 0.83). (A perfect "Earth twin" would have an ESI of 1.)

### Time–Lapse Video Shows Evolution of Universe Like Never Before

May 7, 2014 –

### 'Losing the Dark': Video Illuminates Threat of Light Pollution
To The Stars International Quarterly Editorial Team

L>R: Peter Kokh – kokhmmm@aol.com – http://www.lunarpedia.org/index.php?title=Peter_Kokh

Madhu Thangavelu – thangavelu-girardey@cox.net – Mother from Kerala, Father from Tamil Nadu – grew up in Delhi – now teaching at the University of Southern California – Conductor, Graduate Space Exploration Concept Studio USC School of Engineering & Architecture – co–author of “The Moon: Resources, Future Development, and Settlement”.– Los Angeles, California US

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

Al Anzaldua – alanzaldua706@yahoo.com – President Tucson L5 Space Society, Tucson, Arizona, US

L: Srinivas Laxman – moonshtoindia@gmail.com – Mumbai – correspondent Times of India – author “MoonShot India”
M: Lynn Zielinski, NSS Educational Committee – lzielinski@comcast.net – Chicago, Illinois, US
R: Student Contributor: Aleksandra Voinea – aleksa.voinea@gmail.com – Bucharest, Romania / Yale U. Ithaca, NY

NOTE: Opinions expressed in the Articles & Essays section below are those of the individual writers and do not imply any editorial philosophy of TSSIQ. The TTSIQ editorial team consists of persons of various backgrounds who are free to disagree

We welcome additional co–Editors and Contributors
As well as Reporters from various nations and student groups
Early Supporters of Manned Mars Missions Addressed the Risks Involved

By Peter Kokh

EARLY MARS PLANS FOR ARTIFICIAL GRAVITY, RADIATION PROTECTION
It is NASA alone who is caught off-guard by new Mars-travel “Risk Assessments”

WANTED: Split personality types for Mars Expeditions

By Peter Kokh

A relevant article reprinted from Moon Miners’ Manifesto #30 November 1989

Besides being willing and able to leave Earth, family, and friends behind for three years or more, must for the trip out and back, have a high tolerance for sensory deprivation and thrive on boring routine tasks; and, at the same time, for the period spent on the surface, must be thrill– and challenge positive, keenly attuned to external situations with all their unpredictability. If you are such a Jekyll–Hyde combination, please send your resume to:

- Mars Expedition Personnel Office, Mars Training Camp, Spitsbergen Island, Svalbard

For as long as the era of chemical rockets lasts, interplanetary journeys to Mars or the asteroids, will be long tedious affairs that will be very trying for the kind of people ideally suited for the kind of life that awaits them at their destinations. This presents us with a choice. We can either look for persons with such chimeric personality combinations as suggested above who will perform reasonably well under such diametrically opposite circumstances, or we can start now to plan ways to structure the times of transit to better fit the personality traits of those best cut out for the exploratory and/or rugged pioneer life on the untamed worlds of their destination.

The path of least effort, and a temptation to mission planners, is the former. Transit times will be filled with make work: solar–wind measurements and other astronomical chores that could either be done just as well from LEO, or if not, by robot probes. To this will be added routine periods of exercise and other monastic treats. Meanwhile, people better suited for the planetary surface stay itself, will be bypassed if they evidence any signs of being less content than pigs in a mud hole by such a diet of time–whittling.

We need to take a creative look at alternatives. First, we must recognize that the trip out and the trip home are radically different in the deep psychological challenges they present. Outbound, the crew will be filled with anticipation. Homebound, they may experience both anticlimactic letdown and an impatience to get back home.

The opportunities for damping these feelings with engrossing and meaningful activities are also diverse. In the article “M.U.S./c.l.e.” [http://www.moonsociety.org/publications/mmm_papers/] we suggested that equipment manufactured on Earth for use on the Martian surface be disassembled (all parts tested and checked individual and in test assembly) to be put together in a Big Dumb Volume hold manufactured for the expedition in Lunar Outposts. The crew would be highly motivated to put everything together right. This opportunity will predictably be seen as risky business by some who may favor keeping Mars–bound crews busy performing safer make–work.

Surface expedition concluded, the crew would be similarly motivated to do preliminary chemical and physical analysis of samples being returned to Earth, along with some building materials processing experiments. NASA, however, may forbid them to touch the samples, not trusting them to handle the precious cargo and possibly invalidate intended research by more expert investigators in better equipped Earthside labs.

In both cases, there is probably a point of compromise between NASA’s natural paternalistic prudence and the not unimportant needs of the explorers–en–route. For example, ultra–critical equipment can be shipped preassembled, with less sensitive equipment and backup equipment shipped “KD” (knocked–down) for assembly en route.
For the Earth-return, a similar division could be made. Surface samples could be separated into two quota portions, those held safe and untouched for labs on Earth/LEO, and those on which preliminary analysis and experimentation can proceed en route; trained geologists, chemists, and other scientists will be essential to the crew. To deny them “first rights” can only sow and nourish a festering resentment. Such avoidable psychological compost heaps should not be discounted as threats to the overall success of the mission.

In the overall spirit and atmosphere aboard the return crew vessel is positive, there will be other time-filling things to do. Debriefings and reports while experiences are fresh can be followed by round table discussions of how the success of a follow-up mission could be enhanced (new equipment, tools, lap facilities, housing etc.; better training; additional talents represented in the crew mix, etc.) Sensory and other impressions can be set to canvas or disk by those on board of artistic, poetic, or philosophical bent.

So much for generalities. Undetermined at this time, but absolutely relevant to the matter we are considering, is whether the voyagers will enjoy the amenities or artificial gravity for the long coast out and back. One gets the feeling that provision of at least fractional weight poses engineering challenges that neither Intercosmos nor NASA are eager to tackle. So what if the astronauts or cosmonauts can survive such long periods of zero–G without irreparable harm! The unchallengable reality that the crew of a zero–G ship will arrive at Mars in a physical shape unequal to the demanding tasks at hand in the very limited time frame provided, should be more than enough to convince mission planners to err on the side of patience. One wonders whom they are kidding!

Marsweight, 38% Earth-normal, can be provided by a simple tether arrangement with crew pods at one end and equipment not needed before arrival at the other. Artificial gravity can also be provided more elaborately by a fixed structure, for example by a conjoining for the Marsbound craft as in the Case for Mars I studies.

Experiments with tether–provided artificial gravity could begin soon using the Shuttle and an External Tank brought to orbit with it. We have yet to do an EVA in an artificial gravity environment! An astronaut would have to remain tethered and would share the angular momentum that obtained at the exit lock. It would be tricky stuff at first, fraught with perils that could nonetheless become routine, even as driving in heavy traffic or flying in formation. Appropriate maneuvers and cautious could become second nature. There will be mis–moves but careful provision could minimize serious accidents.

The point to be made here is that, to NASA’s abject horror, no doubt, there is a very real opportunity for totally new tethered–EVA sports outside rotating structures. By shortening a tether to the hub, one would advance on the structure; by paying it out one would fall behind – simple conservation of angular momentum. Using such maneuvers in tag matches might be risky, but rally–type events tin which one faced the clock, one at a time, to land first on a forward perch or tag ring, then on one to the rear, before returning ‘home’, all b manipulating the effective length of the tether, could provide healthy, adrenalin–racing sport. This could be welcome stuff to a crew chosen to be optimally tuned to the pace of activity of the Mars surface part of the expedition. When such sport is embraced, either on the sly or with reluctant official consent, we’ll have come a long way towards making the spacelanes home.        PK

Carter Emmart’s well–known illustration of a craft with artificial gravity en route to Mars
http://www.nirgal.net/graphics/casemars_1.jpg from “The Case for Mars” Vol. 19
Mars Gravity en route to Mars
By Peter Kokh
Reprinted from Moon Miners’ Manifesto #123 March, 1999

At million$ per man hour on Mars, does it make sense to guarantee that the first few months will be unproductive due to the need to recuperate from 6–9 months of zero–G when this could be avoided? Maybe, if it saved anything, the trip home could be done in zero–G, jettisoning whatever equipment mass was necessary to provide rotation. But certainly not on the way out.

It is not a question of physiological health. Perhaps we can keep people healthy in zero–G. That is totally irrelevant. It is a question of readiness to “hit the ground running” on arrival at Mars.

Nor is the other extreme appropriate: sending out our scouts on a ship designed to offer full Earth normal (1G) gravity. Not only would that environment fail to acclimatize them to Mars, it would require 8/3rds or 167% greater boom or tether length and mass – at the same rpm rotational speed.

On the way home, Mars gravity would suffice, shortening the period of rehabilitation to full Earth normal gravity. The crew would not need to be fit to hit the ground running, so to speak. They will be on extended debriefing vacation anyway.

Why do many Mars Mission architects not want to bother? Providing for artificial gravity adds some constraint on Mars ship design, adds weight, and adds a modicum of vulnerability. So what? If we don’t do it, the quality of the return on the mission investment will, with absolute certainty, be compromised. The savings from not providing artificial gravity does not pass the cost/benefit ratio test!

Further, NASA has wasted decades with lip service experimentation with tethers, and no more than paper study experiments with artificial gravity. The agency simply is not ready. It has no reason to feel confident it can pull off an artificial gravity mission. NASA seems to have a cultural mental block against the subject. If that is indeed the case, then, if we are to have the best Mars Mission we can for the money, some other agency may have to be put in charge, even if we have to create one.

We are more likely to go back on sequel expeditions of exploration and go on to establish an outpost at which we can experiment with living on Mars “on its own terms,” preparing for day we can open of Mars as a Frontier for settlement – more likely that is, if we do the very first mission right, and as well as we can. If the rubric of the first mission is simply Mars and back, one word, then doing it right, doing it as an overture to the future – that won’t matter. Quite predictably, we will get as minimalist a Mars mission (in the singular) as possible instead. If you think its been a long wait after Apollo for our yet unscheduled Return to the Moon to Stay, try staying alive after such a first Mars mission long enough to see the next!

BASIC ARTIFICIAL GRAVITY SCHEME

Many people are familiar with the giant wheel station of Wernher von Braun, well illustrated in the 1968 classic Arthur C. Clarke/Stanley Kubrik film: “2001: A Space Odyssey.” Many have also seen artist sketches of Gerard O’Neill’s classic space settlement designs: Bernal Sphere (Island I), Stanford Torus (Island II), Sunflower (Island III). The concept is also key to two TV Series: Babylon V and Deep Space 9. But nothing so grandiose, complex, or vast is needed to effect an artificial gravity environment. All we need is a pair of masses, not necessarily equal, joined by a tether or preferably a boom (to avoid twisting), and set into a spin about the common center of gravity [“cog”] – like a barbell.

The pertinent questions are:
• How slow/fast should the spin rate be?
• How long/short should the tether or boom be?
• Which is more advantageous, tether or boom?
• How do we deploy to the separated configuration?
• How do we spin up/despin the assembly?
• How do we rejoin the assembly components?
• How can we abort from tether or boom failure?
• What items should go into the Consist of each end?
There seems to be widespread agreement that a spin rate of 1 rpm is tolerable by most people, and that a spin rate of 2 rpm may be tolerated by enough people to find a crew. Coriolis effects, which cause dizziness when you turn your head, is the problem to be minimized here.

At 2 rpm, the habitat part of the assembly would have to be 581 ft (162 m) from the center of gravity. At 1 rpm, this distance would be 1062 ft (324 m). The distance from the center of gravity [“cog”] of the Counterweight Assembly would depend on its mass relative to that of the Habitat or Crew Consist. The less it weighs, the longer the distance to the cog, just as the less your friend weighs, the further he or she has to sit from the fulcrum of the teeter–totter to balance the load. By the same token, the less the mass of the counterweight, the greater the total length and mass of the tether. But as the tether or boom should be considerably lighter than either of the two counterbalanced portions, the mass fraction of the counterweight is not a critical concern.

Tethers will be much lighter than booms, and generally easier to deploy (via a simple winch and storage reel). Tests seem to show that a rigid boom is not appreciably more stable than a tether, weighs considerably more, and may indeed have more failure modes. The concern is to avoid twisting at the end of the tether.

If a boom is used, the forces that would build up to induce twist could eventually weaken or even fracture the connection. So it is much better to reduce the tendency to twist, than to try to control it with fragile rigidity. This can be done with a pair of gyros counter–rotating in the plane of overall spin, one inside each assembly. [We have never seen this suggestion made – why not? It need not add much additional mass to either consist, in comparison to all we save by using a tether instead of a boom.]

The two assemblies can be separated with a mechanical shove, the tether being allowed to pay out freely to the set length. Two small rockets, one at each end, vectored slightly outward to counter the bounce–back when the tether limits are reached, fire in opposite directions in the selected plane of spin, just as the tether was reaching full pay out.

When the cruise portion of the journey is over, and preparations must be made to go into orbit about Mars (or Earth), an opposing pair of retro rockets fires in the spinward direction to slow the angular momentum to zero, as the winch reels in the tether.

The tether should not break or snap, the rotational forces being well within its design limits. But the question arises, what if tether should be severed by errant debris or some meteorite? This question has been addressed* but it would seem that the probabilities of this happening, while finite, are astronomically small, and that is the right word.

“A Manned Mars Artificial Gravity Vehicle”, David N. Schultz et alii, pp. 325–352, specifically


Order from: Univelt Inc., P.O. Box 28130, San Diego, CA 92128

WHAT ITEMS SHOULD BE AT EITHER END?

This is a question that has no hard and fast answer. There are pros & cons of safety vs. convenience in putting all the habitat crew space at one end, or splitting it up. Most would keep all personnel together, and we agree. The next consideration is which items must be accessible during cruise mode, and which will not be needed until journey’s end. If this preliminary sort leaves the non–crew assembly mass being too “light,” we could add the expended trans–Mars–injection booster, or we might consider keeping some liquid consumables at that end, accessed as needed through double tubing built into the tether, shifted mass replaced by liquid wastes.

Our next consideration is what type mission are we talking about. A first “Marsandback” mission will need to carry along a landing shuttle and an Earth return vehicle (if not one and the same) if one (or both) had not previously been sent ahead to be awaiting the crew in Mars orbit and/or on the surface. All published Mission Plans that we have seen that work artificial gravity in the design are of this type. In MMM, we have a habit of looking beyond beginnings.

A vehicle carrying pioneers in an era when most stay and relatively few return to Earth, can be designed as a “frog” – amphibious. The crew quarters would be designed to pass through Mars atmosphere, land, and be recycled as badly needed surface vehicle, or extra habitat or lab space: “one way to Mars”. The Mars–bound assemblies need not include anything needed for crew return. The part of the transit chassis that remains in Mars orbit, could be tugged or barged back to Earth to be reoutfitted with new passenger modules to bring more pioneers.
All the designs I have seen are apparently for chemical fuels. The barbell design is especially right for Nuclear Ships. The large separation between the units will afford added radiation protection for the crew and passengers, the nuclear plant being housed at the opposite end of the boom or tether. The “cycling” Mars ships proposed by Aldrin and others could be quite large, with permanent artificial gravity designs, plying the Earth–Mars run continually for decades.

Design options are many.

Craft bringing Lunans to Mars might start the trip at 1/6th G and gradually work up to 3/8ths G on the first half of the journey, leaving time for Moon–acclimatized people to get used to the heavier load. Another special case has native–born or naturalized Martians traveling to Earth. Again, the journey could start at 3/8ths G and build up gradually to full 1G.

We need to bite the artificial gravity bullet, not just on the drawing boards, but in low Earth–orbit testbed facilities where we can afford trial and error. This minority view must prevail.

NOTE: artificial gravity is NOT a feature of the Mars Direct mission architecture in so far as it incorporates the ARES shuttle-derived vehicle. But that vehicle is not essential to Mars Direct. From this point of view, the Mars Direct mission architecture needs to be reviewed. Getting there fast and cheap is no good if you get there physically incapable of performing on Mars itself!

We think that a redesign is possible that would provide Mars level gravity for the trip to Mars. As the return to Earth will be in a different vehicle, that poses a separate question, but one less critical for mission success.

Any “Humans to Mars” Mission Plan that fails to provide artificial gravity enroute, is not quite ready to be taken seriously. – [True in 1999, true today – PK]

---

**Artificial Gravity enroute to Mars and back strongly advised**

Reprinted from *Moon Miners’ Manifesto #153 March, 2002*

By Peter Kokh

Why there is a need

While some brainstorm designs for Mars-bound craft have included provisions for simulating gravity, most writers and designers dismiss the need. Admittedly, such a design requirement would make the craft heavier, more expensive, and because of the added weight, such a craft would require a more robust and more expensive propulsion system – all conditions to be avoided. But hold on a minute! Compare that extra expense to the cost of minutes wasted on Mars by crew members taking time to get their legs back so that they can use their priceless hours on Mars to accomplish the goals they came to do! Most of us are aware how helpless persons find themselves on returning to Earth after a year in “zero-g.”

**There is no comparison of the cost of wasted time on Mars to the cost of avoiding the problem by providing shipboard artificial gravity** – at the 3/8ths G level they will experience on Mars, and which would allow them to “hit the ground running.” The tipping of the scale is so very self-apparent that it makes one wonder what universe proponents of zero-G transit to Mars are living in. Zubrin’s “Mars Direct,” NASA adaptions thereof, and Elon Musk’s Falcon Heavy Mars trip scenarios do not address this problem, despite its obviousness (when you think about it in the terms stated above.)

Now if the pennies need to be pinched, the crew could return to Earth in “free fall” as there would be no such urgency to get back on their feet on arrival. Like the MIR and ISS astronauts returning to Earth after very long stays in space, they would eventually recover for the most part. Permanent vision problems reported are hardly disabling. Most people lose some visual acuity as they age anyway. (This writer gets to see 2 or 3 stars where everyone else sees but one. But I can still type and do all I need to do. It’s not fatal!)

If we do provide artificial gravity on the return trip, it could start at Mars-normal 3/8ths G and gradually ramp up to full Earth-normal gravity by arrival, so that the returnees could hit the lecture circuit right away!

**How we can provide artificial gravity en route**

We do not intend to go into design options in this article. To help you visualize the options, consider the artificial G rotating circular running track in the classic film 2001: a Space Odyssey. There are a number of other films where set designers have gone where no NASA designer dared to go.

Rotating cylinders are the common answer. They do create a problem as their rotation would induce a counter rotation in the rest of the vehicle and that is to be avoided. A pair of mutually counter-rotating sections is one answer. A simple flywheel turning in the opposite direction would be much simpler.
Most of the illustrations show a very short radius which might induce coriolis problems. The simple trick of colored directional cues, with experience, would keep crew members from turning too fast in certain directions.

Another solution that has been advanced, is to divide the ship into two sections, crew quarters and everything else, pay them out and apart on a tether (a twist-resistant beam or truss would work much better if it were collapsable) then induce rotation about a common center of gravity.

Now there is an ideally perfect option: thrust at 1 G halfway to Mars, flip directions and decelerate at 3/8th G until you arrive. Unfortunately, we know of no “engineerable” way to do this, or of no propellants with this much oomph for the same mass. With such a system, one could get to Pluto in a week, if I remember correctly (I did the math for all Earth to planet destinations 3 decades ago, on paper, and have no idea if that sheet of paper still exists. Oh yes, to Alpha Centauri in 3 years and we know that isn’t going to work! Jerry Pournelle did the math as well, I believe, and it may be in one of his paperbacks. Back to the real early 21st Century!

Our purpose here is not to pick the ideal engineering solution, but to help ostrich-minded designers to take a peek at the real world and abandon and start from scratch. Look at all the options and their variables and weigh the plusses and minuses of each, compare the nickels and dimes, determine what needed technology and engineering items are not yet on the shelf, and in general, get to work and give us some real designs.

And Oh, by the way, if you can give us some shielding while you are at it, enough shielding so that we can make the Earth–Mars run and Mars–Earth run in Active Sun periods as well as in Quiet Sun years, that would be marvelous. It would be a pity to send out a crew on a very expensive mission only to have them fried on the way by some unexpected Coronal Mass Ejection solar flare event. Now to be honest, these events are directional, and by luck none will expand in the vector our Mars–bound or Earthbound ships are traveling. The gambler needs to know when to fold the cards, however.

If we are only going to send a ship or two to Mars just to say “Kilroy was here” on an expensive remake of “Flags and Footprints I” perhaps we can take the gamble. But if we are going to stay, the only option that makes any sense at all, including economic sense, then we need to gamble intelligently.

**Calling all readers** If you find any designs of Mars–run ships that provide artificial G – online – please email MMM the URL (web address) to kokhMMM@aol.com

**NASA’s Timid record on Demonstration of Artificial Gravity in Space**

Not only had NASA not prioritized experiments with artificial gravity, Robert Zubrin’s “Mars Direct” architecture had no place for it as well. Nor does any other Mars Transportation Architecture that we have seen or are aware of – EXCEPT those proposed by dedicated amateurs, determined to it right, as is clear from The Case For Mars series of Conferences in the 1970s which contained a number of papers containing architectures for Earth–Mars transit vehicles that provided artificial gravity.

The LS Society’s plans for “Space Settlements” also provided artificial gravity for living environments for workers who would build Solar Power Satellites to boost Earth’s economy. Indeed, these designs were published in NASA’s own

But that did not mean NASA would take seriously these designs, or the need for something similar,

To be fair, NASA has never had freedom to design according to need, in an economic atmosphere that meant “spartan, or not at all.” It is more fair, and proper to put the blame on Congressional dimwits for whom “do it right or don’t do it at all” is a principle that they don’t understand.

Not a detailed account of NASA’s record, but a simple statement of facts

Yes, NASA uses centrifuges to test the acceleration tolerances of would-be astronauts.

Early plans for a small centrifuge “on board ISS” to test reactions of small animals were dropped as a budget concession.

NASA has always been afraid to challenge Congress: “we should do it right or just not do it at all.”

Physics does not allow “political compromise.”

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

Original plans to provide artificial gravity were cancelled in 2005 ‘because of ISS cost overruns and scheduling problems in Shuttle assembly flights.’

**Notes:** Artificial Gravity is not crucial for short 3–day trips to the Moon or Back

The weight penalty: “just a boom” and apparatus to spin up the structure, and spin it down. ##
Avoiding “Cabin Fever” on the Moon and Mars

By Peter Kokh

http://en.wikipedia.org/wiki/Cabin_fever – Cabin fever is an idiomatic term, first recorded in 1918 for a claustrophobic reaction that takes place when a person or group is isolated and/or shut in a small space, with nothing to do for an extended period. Cabin fever describes the extreme irritability and restlessness a person may feel in these situations.

A person may experience cabin fever in a situation such as being in a simple country vacation cottage. When experiencing cabin fever, a person may tend to sleep, have distrust of anyone they are with, and an urge to go outside even in the rain, snow, dark, or hail. The phrase is also used humorously to indicate simple boredom from being home alone.

BACKGROUND:
Purdue students pitch Moon colony plan to NASA


April 17, 2014 – A Purdue University senior design class has a plan to colonize the Moon. The mission’s overall success rate is 80%, The odds of the colonists not returning safely to Earth is about 17%. “This is a little bit high. But we have to consider that we’ve never done this before. This is 8 times longer than our astronauts have ever stayed in space.

“Cabin fever is a real concern.”

How to Avoid “Cabin Fever”

Myopic and minimalist plans of NASA (or of other space agencies) for a “starter” outpost on Moon or Mars in support of scientific field work, including experimentation with materials made from Moon dust or Mars dust, would seem classic cases of design myopia, sufficient for short tours of duty but no more. Yes, “anything worth doing is worth doing right!” But you can't do anything “right” if you don't look ahead, far ahead.

Mentality is Number One:

Drop the “minimalistic” approach to Moon and Mars Outposts! We go not just to explore and investigate – yes, we do do that! – but more importantly, we go to prepare the establishment of a permanent presence on a new human world and expand that presence Moon/Mars-wide.

Getting used to scheduling tasks appropriate for Dayspan, then Nightspan

• Power–hungry tasks must be done in the 2–week long Dayspan: mining, manufacturing, construction, etc.

• Labor–intensive, power–light tasks saved for the 2 week long Nightspan: repairs, inventory, planning, packaging, etc.

An “Interesting” Site: Picking a site not just for resources, but also for interest

Here we are not concerned with where to set up camp first, though personally, we disagree with the “rush” to the Moon’s south pole. No here we are concerned with the design of an outpost, the amenities
afforded, the diversity of tasks needed to support the outpost operation, and more. The needs for morale may seem irrelevant in choosing a site. But that is short-sighted. Long term, a site that is interesting enough to keep morale high and motivate crew to “re-up” for another tour of duty, cuts in half the cost of supplying crew from Earth.

Site features that reduce boredom and boost morale
- Pick a “border” site where two or more types of terrain converge: highlands and mare plains, for example. This will accelerate local production of items that won’t need to be shipped from Earth.
- Nearby scenic attractions: hills, rilles, overlooks, lavatube skylights, etc.
- Interesting “explorable” scenic locations with scenic overlooks
- Outlying camps and activity areas
- Alternate paths and trails for different lighting conditions as well as just for variety
- Planned and opportunistic road and path construction as a supporting activity
- Sorties to out-of-area locations reachable overland or by hop flights.

Interesting Accommodations
- Modular Design: pop-out, fold-out module designs (cf. current travel homes/coaches)
  2 floor horizontal cylinders are the best compromise between portability and floor space per ton
- Comfortable suites/personal customizable quarters with changeable decor
- Virtual elbowroom – movable partitions
- Windows to the surrounding terrain (TV screens could be fed a false, non-live view)

Bringing the Views & Sunshine Underground
- Bringing in the sunshine during dayspan hours with light tubes, sulfur lights during nightspan

One Improvement at a time
Many, if not most of the suggestions below can be introduced as the number of personnel on the Moon grows. And as the physical complex expands, and as the scope of activities broadens, new features can be introduced. If this expansion-diversification strategy is followed, enthusiasm, morale, and role
satisfaction will tend to remain high, and that will translate into greater productivity, both of the outpost and of its crew. And an increasing number of personnel will choose to “reup” again and again, until they come to feel like permanent pioneers.

**Commons that support a variety of recreational and social activities**

- Tubular walkways between connecting habitat and activity modules would provide more space for vegetation in the form of **Living Walls**, with **water features**, flowers, maybe some small birds.

- Outdoor spaces can be given a human touch (raked **zen gardens** with placed lunar boulders; carved basalt sculptures, sculptures made out of scrap (no longer needed items)

**Expansion Options**

- New modules as population grows and activities diversify, new activity areas, new scenes
- Expansion activities of all sorts
- Nearby sites with access to additional resources:
- Adding new out-back support facilities for science, materials hunting, tourism
  - Expanding the home campus and outlying campus areas

**Expanding “Local Sourcing” to minimize imports**

- Cultivation of new low-gravity vegetation and garden varieties to supplement upported food items and other products which can be made from plant materials
- Making useful items from local materials: moulded and sintered moondust, carved basalt
Escapes; Changes of Scenery

- Switching assignments with personnel at other outposts
- Lee-Vac Game/Sport fields: for trying out new games that play to low gravity and zero air resistance
- Virtual Reality Vacations elsewhere, including other worlds.

- Vacations at L1 or L2 stations for those too adapted to lower gravity levels to return to Earth itself
- Vacations at a resort in the heart of the “Peekaboos” (the shifting boundary between “nearside” and “farside” within 7° either side of 90° East or 90° West) from which Earth and the Farside Heavens are alternately visible. Add various fun activities and excursions, and personnel will return to duty refreshed and renewed.

  Mind and soul–expanding views of the farside heavens with Earth “out of sight and out of mind”.

Part time Hobbies and Recreation Options

- Agriculture and intermixed floral gardens in the commons as well as in one’s home space
- Fish tanks, birds, indoor pets
- Hobby provisions of all kinds, especially those adapted to lunar materials and conditions
- Low gravity dancing, even ballet!
- Low gravity acrobatics
- Low gravity sports (caution, momentum remains the same!)
- Experimental and adapted games, indoor, outdoor
- Rock collections, rock and moondust–based arts, crafts, creations
- Landscaping, rock gardens
- Experimenting with other arts and crafts based on local lunar or Martian materials
- Rotating assignments between locations for a partial change in “base mates”
- Designing and creating Lunar/Martian Frontier furnishings and furniture (cast and sculpted basalt, rocks; glass, sintered moondust etc.

A cast or carved basalt Mancala or Oware game board – plus a set of pebbles

(one of the top ten games of all time in strategy required)

Floor and wall tiles, planters, sinks, tubs, countertops and sculptures from cast, hewn, or carved basalt
Outlooks Recreation Opportunities

- **Shielded unpressurized canopies** for outvac activities in light-weight suits will allow development or new sports for Lunar and Martian conditions. Warehouses for frequently accessed items could be similarly sheltered too.

- Hiking trails, especially in non-flat highland terrain
- Unique vehicles: go-anywhere “cagemobile” and spider high-riding go-anywhere coach

- Reinventing the space suit: pressure skin-suit plus loose thermal outerwear. “Skinsuits” can be embarrassingly revealing. Loose outerwear solves the problem and allows individual expression
- Amateur Astronomy

Varied Job Assignments

- Rotating job assignments
- Shifting assignments between separate but reachable locations
- Prospecting, etc.
- **Nightspan – Dayspan assignment rotations**, specialty free time opportunities in each

End of Tour Opportunities and Alternatives

- Freedom to “re-up” (stay for another tour of duty without going back to Earth first)
- Freedom to mate
- Eventually, freedom to bear and raise children (a very big leap and commitment!)

Back to Basics and Number One: Recruiting People with the “Right Stuff”

- “**WANTED: Persons who are:** Curious, creative, adjustable, questioning, Inventive, multi-disciplinary, multi-hobbled, exploratory, cheerful, friendly, cooperative etc. – qualities as important and as crucial as occupational talents and expertise.”
Other ways to Cut Expenses

- **Paying (not paid) volunteers:** people pay good money to participate in paleontological and archeological digs. There will be plenty of well-heeled volunteers ready to pay for the privilege of pioneering the Moon and Mars on both short and long-term assignments.
- **No throwaway transportation equipment:** rockets refueled in space, cargo holds designed to serve as storage modules, corridor modules, even habitats,
- Nothing should be landed on the Moon without being “co-designed to serve new functions there.
- **Any scrap is fair game for wood-be sculptors**

**Antarctica’s McMurdo Sound base is the ideal place to practice and preview**

Ideally, many features of such a plan might be pioneered in Antarctica by granting appropriate privileges to volunteers at McMurdo Sound, the “metropolis” of the 7th continent. This has to be thought out carefully, but “any enterprising” expansion of the McMurdo operation will help pave the way for what we need to do on the Moon.

- **Securing the right to try startup enterprises** using local materials (in so far as allowed by Treaty, e.g. loose rock that isn’t “mined,” abandoned objects and materials, and the base scrap pile
- **The right to stay on after a tour of duty is finished,** if housing is available and one is self-supporting (or funded by a benefactor or outside organization)
- **The right to contract with the base** for desirable services not previously provided
- **The right to apply for open jobs** when one’s tour is over.
- **The right to form, with others, an “enterprise” “village/suburb”**

**Upshot – the writer's view**

If we follow the above suggestions in planning a serious outpost/base/station (that is, on site materials based industries – not just scientific exploration and sampling,) the chances of “Cabin Fever” setting in will be greatly reduced. And as an invaluable consequence, the number of “quality” volunteers from Earth – with the real “right stuff” will continue to grow by leaps and bounds, many of them choosing to stay for another round of duty and service, reducing crew replacement costs. Some may choose to stay indefinitely, making the Moon “home.”

But we cannot rely on the political process to make the right decisions. As justly proud as we may be of NASA’s achievements, settlements beyond Earth are economic ventures, and the commercial sector must take the lead. Only the commercial sector, by doing things for economic reasons, can bring down the cost of humanity’s expansion beyond our home planet, as it already has in GeoSynchronous Orbit where the economic value of operations there already exceeds $300 billion a year, enough to warrant giving GEO a seat in the G-20!

Nor will an International coalition of national space agencies get the job done right on the Moon, much less escape the pitfalls of “Cabin Fever.” We can be grateful that these agencies continue to undertak scientific scouting missions in an era before economic opening of the Moon becomes feasible.

Mars is the tougher challenge. There are multiple economic reasons for opening the Moon, as by far the cheapest source of materials and products needed in Geosynchronous orbit, but to our knowledge, no one has come up with a single economic motive for opening the Martian Frontier, however much we all want to see that happen. Yet Mars is a natural trading partner of a lunar frontier, and that prospect may be the place to start.

It follows that without the Moon, the Martian frontier might never get beyond the scouting stage, however much more “Earthlike” a world it seems to be, or could someday become.

More significantly, the first real step to Lunar (and eventually Martian) Settlement will have been taken. That may not be NASA’s goal nor the goal of any other national Space Agency, but it must be Our Goal and the Goal of those who sign up for a tour of duty.

**To succeed, we must take measures to avoid “Cabin Fever.”**

PK

Read also:

- **Assuring Mental Health Among Future Lunar Frontier Pioneers** © 2008
  Reprinted in **To The Stars International Quarterly #6**, pp. 83–91

- **The Outpost Trap: Technologies Needed to Break Free**

- The various “Theme” issues, currently 17 in number.
Background
Cube satellites ("cubesats") are a well established technology for inexpensive Low Earth Orbit (LEO) missions and are widely used in education, research, and military applications. Their use in cislunar space is the next extension in their development. In this regard, we present the case for a series of cislunar development and demonstration missions to:

- Advance and demonstrate their technical capabilities
- Demonstrate their scientific utility
- Demonstrate their usefulness with regard to infrastructure development
- Demonstrate their usefulness with regard to commercial applications

Cubesat scale spacecraft provide the potential for much more affordable means of working in cislunar space than larger heritage systems. This potential, however, must address substantial technology challenges to advance science and commercial goals. Cubesats can be launched as inexpensive secondary payloads. They are most often ejected on EELV Secondary Payload Adapter (ESPA) rings with spring-launch mechanisms and often use solar–electric ion propulsion.

These propulsion systems face several constraints and challenges:

1) The size of cubesat solar arrays is limited\(^1\) by the small scale of the spacecraft;
2) Their fuel mass is limited, but is "leveraged" by much higher Isp than chemical propellant systems;
3) Attitude control for ion propulsion systems is currently a technological challenge that should be achieved in the near term;
4) Ion propulsion systems typically produce low levels of thrust, effective over long periods of time, but with limited ability for rapid changes in velocity.

Navigation
Cubesat propulsion systems must be carefully matched with low energy trajectories to meet complex mission requirements.

Communications
The small size of these spacecraft present additional challenges, including:

1) The low strength of the signal broadcast (in the range of 10 – 12 watts) due to the limited scale of the cubesat solar power system;
2) Limitations on bandwidth;
3) High–cost communication requirements of the large dishes for signal reception. Less expensive systems than the Deep Space Network are needed;
4) The small scale of cubesat antennas may be enhanced by inflatable antennas with reflective arrays.

Power Systems
The 10 cm x 10 cm solar panel “face” of the standard cubesat can be enhanced by a fold–out panel array. Enhanced or not, small solar power surface areas provide an incentive to develop and test higher efficiency solar cells. Such fold–out panels could also serve as solar sails to provide a fuel–free supplement to the thrust of the ion–engine, thus serving a double purpose of power and propulsion. Their control by gimbal stabilization systems can optimize their power reception and their impact on mission propulsion requirements. Extension or retraction of these panels may be significant at the edge of a planetary atmosphere, when aerobraking or controlled de–orbiting is needed.

Electronics
One cost advantage of cubesats has been their use of low–cost consumer electronics. The increased mission risk has been counterbalanced with redundant systems and most often short duration missions in LEO. Redundant systems drive up mass and power requirements, however. The use of low–cost electronics to the point of failure has been an acceptable strategy for these missions. Careful analysis of the most probable failure points can direct design. Other factors are:

- The use of radiation–hardened electronics drives up the cost, but reduces mission risk;
- Using smaller components reduces the cross–section exposed to radiation;
Extreme temperature range mission requirements may offer demonstration opportunities for electronics operating at low power and temperature. Infrared observations utilizing compact cryocoolers and superconducting circuits could be tested within the cislunar environment and within permanently shadowed regions of the Moon. There has been at least one proposal for the use of a compact cryocooler with an infrared spectrometer to investigate lunar polar cold traps to better characterize frozen their volatiles.2

**Low Energy Trajectories in Cislunar Space**

Dr. Edwin “Buzz” Aldrin has been an early and outstanding advocate for the use of cycling orbits, both for cislunar space and Mars.3 (Also see Dr. Aldrin's Unified Space Vision graphic below.)

Low Energy Trajectories in Cislunar Space

Dr. Edwin “Buzz” Aldrin has been an early and outstanding advocate for the use of cycling orbits, both for cislunar space and Mars.3 (Also see Dr. Aldrin's Unified Space Vision graphic below.)

John 8. Lewis and others have identified a variety of low energy trajectories which might provide opportunities for relatively low cost cubesat scale demonstration space missions.4

![Unified Space Vision graphic](image)

T. A. Heppenheimer, for example, suggested a 2:1 cycler resonance orbit5 which at the perigee is about 100,000 miles from Earth's surface and at the apogee about 200,000 miles from the Earth's surface and therefore periodically within striking distance of the Earth–Moon Lagrange point L1 and 2 for very small changes in delta-v. (See below graphic from his book.)

![Credit NASA](image)
Recent observations of small asteroids or “mini–Moons,” which enter cislunar space and remain in complex orbits for periods of a few months to a few years, raise the potential of cubesat scale missions to more closely observe these objects and characterize their composition and structure.

Lunar cubesats might provide opportunities for a succession of low cost missions to demonstrate new technologies, test low energy trajectories for specific mission objectives, and address other objectives in astronomy and planetary science.

Mission proposals, which require a fly–by of a mini–Moon, could also test and demonstrate ion and/or electro–spray propulsion systems. A cycling orbit might also be favorable for “close in” detection of Near Earth Objects (NEOs). More advanced and robust propulsion systems might be developed for the ambitious objective of matching orbits for detailed characterization and sampling of mini–Moons. These technology developments might have applications to characterize and plan the removal of “Zombie Sats,” which have ended their useful life, including other large space debris objects posing a threat of a “Kessler syndrome” cascade of satellite collisions in LEO, MEO, and GEO.

Conclusion

The Case for Cislunar Cubesats is not so much an argument for one specific mission, but for an exploration of many interrelated missions wherein technology could be developed using low–energy trajectories to advance scientific objectives. In this context, Dr. Aldrin’s approach represents a synergy of science and engineering.

Notes

1. 10 cm x 10 cm x 10 cm
Lunar CubeSat Projects, Mission Proposals, and Technologies
By David Dunlop – June 2014

Lunar CubeSat Missions and proposed projects serve a range of purposes and options. New ideas are being developed in many places. Several ideas for Lunar Cube Satellites have been considered in the last several months by Flexure Engineering in Special Interest Groups. Other projects are being developed with NASA support or as NASA proposals by university research or of those developing technologies:

These Missions whether in active development or a proposals reflect a trend that are expressed in the International Lunar Geophysical Year Campaign.

1 A Cislunar Radio Beacon

A 1U radio beacon which would serve the purpose of calibration for radio telescopes.

This has been discussed in conjunction with the SETI Institute by Flexure Engineering.

B This idea has also been the subject of an AlaNa proposal by University of Hawai‘i, Manoa Ho'oponopono: a 3-Unit CubeSat supporting orbital radar calibration capabilities by providing a source for radar interrogations. Dr. Wayne Shiroma listed in work on 2012 list

C Courtney Duncan of JPL had a cubesat radio beacon project during the ALANa program listed for 2012: Item #14 LMRSat Low Mass Radio Science Transponder Satellites 2U listed as in work.

D This ideas has been the subject of some discussion in the Deep Space Communications SIG organized by Flexure.

2 A Cube satellite spacecraft health monitoring system which would monitor and report the status of cubesat spacecraft systems and sensors. This is another project that has been the subject of some discussion in the Deep Space Communication SIG group.

3 A Lunar Water Distribution Mission (LWaDi) using a solar electric ion propulsion system to provide highly elliptical polar orbits using a compact cryocooler and an IR spectrometer to better characterize lunar ice deposits in permanently shadowed regions has been described in a 2013 LEAG abstract. This proposal was put forward by Pamela Clark, Bill Ferrell, and Russell Cox. Thus far no mission development funding source has been identified.

4 An ESPA Ring Mother Ship which would carry a number of other cubesatellite spacecraft which could be dispatched to rendezvous with mini-Moon asteroids in cislunar space. Other possible secondary lunar cube missions might also be carried on this ESPA Ring mother ship. These discussions are in part a result of considerations of development work of ESPA ring design work underway at the Moog CSA corporation and presented by Russell Cox during the iCube Conference at Cal Tech n 2014. This option is something also that has been enabled by the initiation of a secondary rideshare program by Space System Loral coordinated with NASA AMES and also presented at iCube Conference in May at Cal Tech.

5 Another proposal is the development of a Lunar 50 series of satellites after the model of the QB 50 environmental cubesat network. The science rationale for this network idea is perhaps not as clear for the Moon’s environment as for monitoring the Earth’s environment. But the power of engaging a global network of universities for example is of significance. This idea may be a Phase II initiative of the ILGY campaign. It needs a core science rationale. It needs a collaborative network to push this proposal. It needs a “big picture sponsor”

6 Carl Brandon at Vermont Technical College has completed an initial LEO cubessat mission. His objective is to complete a lunar cube mission. He has the prospect of funding this objective in dribs and drabs beginning with small amounts of Vermont Space Grant Funding. Carl is familiar with the Bucek propulsion system as a option for a lunar cube propulsion system.

It is not clear if there is a specific science mission purpose that Carl has selected for his mission and it might be an open consideration which cold provide a path for potential funding of further mission development.

Carl’s breath of experience in both space craft fabrication, computer systems, and the launching and operation of his satellite make him a significant prospect for future Lunar cube sat mission development. Carl is interested only in working with others who have had prior successful cube sat mission experience.

Courtney Duncan at JPL might meet this criterion of prior experience and JPL might also be an institutional partners with a credible chance of funding development.

7 The Lunar Swirls Mission developed by Ian Garrick Bethel at UC Santa Cruz with collaborative support on the magnetometer from UC Berkeley, support from NASA AMES, the Khung Yee University in S Korea with some KARI support, and the University College in London will provide two impactors on the lunar surface that will transit lunar areas where magnetic anomalies have been detected. Estimated Mission cost is between $5M and 10M.
8 The **Lunar Flashlight** Mission under development at Marshal Spaceflight Center will use a Solar Sail as a reflector of sunlight into the permanently shadowed areas of the Moon where an IR detector on the spacecraft will provide information on the water abundance in those areas. PI is Barbara Cohen. Estimated cost is $20M with civil servant costs included and $12M without.

9 Rensselaer Polytechnic University has proposed a $24 Million mission to rendezvous with an asteroid.

10 Utah State U. has proposed a cubesat mission to rendezvous with an asteroid at a cost of $14,000,000.

11 **CryoCube**: A cubesat–Scale Testbed for Cryogenic Field Management Technologies NASA Kennedy Space Center Justin Olivera 3U listed in work on 2012 ALANA list. Another category of ideas is that of technology demonstration test-in-space mission which push cube satellite technology capabilities out to cislunar distances: A variety of mission ideas have been put forward from diverse sources.

12 Use of a Refractory Dish for Ka band transmissions and reception over cislunar distances.

13 Use of radiation tolerant electronics design analysis of radiation environments and risk with the iRad Tool Guide:
   - Analyze risk associated with each component selected for the satellite
   - Analyze risk association with shielding techniques and associated mass requirements and
   - Analyze the mission operational pattern of when the electronic systems can be turned off thereby diminishing the risk of electronic latch-up events.
   - Predict the total accumulated radiation dose expected during the mission life and it the statistical impact on mission reliability at various milestones.

14 Use of solar arrays which can provide a power budget and which also have gimbal systems so that the arrays can be pointed toward the sun for optimum performance as well as positioned so that these arrays can also be positioned as solar sails in providing fuel free propulsion effects.

15 Use of higher efficiency solar cells and more complex PVC multi-junction materials to increase the solar power conversion efficiency and the long term testing of such systems. MMA–Design is a Boulder Colorado based company with design and cubesat experience including with the AF Academy. Leslie Seal is CEO and was at LSA#4.

16 Matching mission requirements and low energy trajectory options with specific ion propulsion technology options based on both cost, performance, and technology development goals. Goddard Space Flight Center has a group that is working in this area doing mission modeling. JPL has capabilities for mission planning in this area as well.

17 **Use of solar powered ion propulsion systems.**
   - The Busek company has options for use of conventional Hall effect thrusters with high cost xenon propellant which represent a Heritage Design technology.
   - Busek is also planning to test iodine propellant which is lower cost but has some performance risks associated with its utilization.
   - The University of Illinois has also proposed the use of teflon as another low cost propellant option for ion thrusters and done some work in this area.
   - Other ion and electron propulsion systems are in development at Michigan Technology University at their Space Propulsion Lab (Dr. Brad King). Their work is being funded by the AFRL.
   - The University of Michigan is also another member of the AFRL funded network. They have proposed an ion propulsion system using H2O with an isp of 10,000.
   - NASA has also funded ion propulsion development programs and a better picture of their technology partners is needed. I believe both NASA Glenn and NASA.

**CubeSat Resources**

**Cubesat Design and Project Resources:**

1. CubeSatShop.com is an ISIS initiative. EyasSat is a fully functional nanosatellite designed for teaching spacecraft systems engineering in the classroom and laboratory developed between the US Air Force Academy and Colorado Satellite Services.

2. Sci_Zone satellite design and project development software QuickSat.com

3. ADA SPARC software has a self editing capacity that reduces the error rate of software code to 1 in 10,000 lines. And reduces the risk of software errors causing the failure of spacecraft.

4. ClydeSat, Glasgow, Scotland

**Cube Satellite Mission Development Options:**

I have presented the Cubesat development scenario this far looking at Vermont Technical College as the Institution which might be a primary developer and fabricator fabrication of a lunar cubesat. Other development options might similarly involve JPL. Mohammed Moharaji indicated that his boss at JPL might insist on JPL as the prime and lead agency for the mission.

A third options might be the Falconsat Program at the Air Force Academy and its strong connection to the Space Test Program of the Air Force Space and Missile Command, and other Air Force. ##
After Russia Leaves the International Space Station

By Dave Dunlop

1. The International Space Station is testimony that it has been quite awhile since the Soviet Union Collapsed (12/26/1991) and the MIR space station was dumped into the ocean. (3/21/2001) A greatly weakened Russia signed on to the ISS partnership. Deal were worked on the disposal of nuclear materials at the end of the cold war and the US provided economic assistance to keep the Russian space program and scientific and technical engaged when their personnel might have been less productively engaged elsewhere. When the Challenger was lost the Russians kept the ISS functioning during the extended stand down of the Shuttle program. But those were actions taken under circumstances of economic necessity and desperation.

2. Now we see Russia asserting itself to protect what it sees as its vital political interests in Crimea and Ukraine much to the chagrin of the United States and the European Union. The Russians have looked at the ISS bargain and said they are willing to walk away and intend to do so in 2020 in part in response to US–EU sanctions applied to them.

3. After almost two decades of collaboration on the ISS it somehow surprises us that Russia would want to reassert its independence in Space. Yet the role of the Soviet Union as “the other superpower” has not been forgotten in Russia. Now that Russia has undergone a transformation in its economy in the last twenty years it seems ready to assert itself in space once again as an independent force.

- Russia has just approved a 6 billion ruble budget through 2020.
- Russia is pressing forward to complete a new modern rocket facility, Vostochny, in Siberia.
- Russia has developed a launch facility at the European Space Agency’s spaceport in Kourou (French Guiana, South America) (for launching into equatorial orbits).
- Russia has indicated it will still make active use of Baikonur in Kazakhstan.
- Russia has been developing a new Angara rocket family to replace the vintage Soyuz–Progress systems that it has relied on for decades. The Angara will not use the old toxic propellants.
- The ISS Russian components could form the core of a self-sufficient Russian space station which could be further expanded with new modules, already in the works.
  A. A Multi-purpose Lab Module (MLM) scheduled for launch in this year (2014).
  B. A Node module with a large Russian airlock would follow the MLM in about a year.
  C. A pair of planned Science and Power modules is also in development would provide an independent source of power for a Russian space station.
  D. Russia has announced an ambition lunar mission program with 5 lunar missions planned, Lunar 25 through 29 including four landers and one orbiter. Three of the landers will be sample return missions.
  E. Russia has announced its intention to place humans in a permanent base on the Moon.
  F. Russia is also expanding its Glonass positioning satellite system.
  G. Russia is also planning Mars missions.
  H. A next generation outpost, the OPSEK project would use the newest modules brought up to ISS.
  I. Russia’s RKK Energia is studying an experimental inflatable module which could attach to the Russian station.
  J. A man-tended platform at a Earth–Moon Lagrange point.

The Point: By 2022 the ISS may have seen its Russian sponsors leave to establish their own station. The Chinese may have their Tiangong space station under way as well. I suspect that there will be three International Space Stations each of which serves the economic and political interests of its main economic sponsors. The ISS may also evolve under a variety of scenarios with commercial components. ##
Land a Lunar Laser Reflector Now!

http://www.space-travel.com/reports/Land_a_Lunar_Laser_ReflectoR_Now_999.html

By Morris Jones, Sydney, Australia (SPX) Apr 04, 2014 [TEXT ABRIDGED]

As we consider the next spacecraft to land on the Moon, let’s not overlook an increasing problem in scientific research. The laser reflectors already on the Moon are getting old, and need to be replaced. Laser reflectors are collections of prisms or mirrors that bounce light back in exactly the same direction of its arrival. This means that it’s easy to fire a laser beam at the reflector and see the beam travel straight back to you.

Laser reflectors were placed on the Moon by the Apollo astronauts and were also carried aboard the Lunokhod robot rovers landed by the Soviet Union in the 1970s. They have no moving parts and need no power source. Thus, these laser reflectors are the only experiments left on the Moon by those missions that still work.

Laser reflectors are fairly easy and cheap to manufacture, compared to other scientific payloads. The major issue with deploying them on the Moon is their orientation. They must be turned to face the Earth, for obvious reasons. It’s important that they are not obscured by nearby mountains or crater rims.

Scientists have been using the laser reflectors regularly since they were placed on the Moon. They have shown that the Moon is steadily moving away from the Earth by a few centimetres each year, as it has been doing for millions of years. In turn, this is causing the Earth’s day to grow slightly longer. Physics, lunar exploration, tidal studies and Earth sciences all benefit from the use of these reflectors.

The reflectors are robust devices that work well, but we cannot expect them to serve us forever. Abrasions from micrometeorites are slowly ruining their optical surfaces. Dust can also coat them, obscuring them further. The vicious thermal cycles of the Moon also place stresses on their materials. Scientists using the reflectors have noticed that they seem to be deteriorating, and reflections are no longer as strong as they used to be.

No laser reflector has landed on the Moon in over 40 years. The most recent spacecraft to land on the Moon, China’s Chang’e-3 lander and rover, did not carry one. To be fair, Chang’e-3 was packed with more experiments than most lunar missions, and most lunar landers (including some of the Apollo missions) did not carry laser reflectors. We don’t really need a lot of them, but it is vital that there is at least one reflector in reasonably good condition at any given time.

How can we get another reflector to the Moon? An obvious choice would be to place one on the next mission to land there. That could well be Chang’e-4, China’s follow-up lander mission to Chang’e-3. We do not know if China is considering a laser reflector for this mission, but perhaps they should.

Laser reflectors are fairly easy and cheap to manufacture, compared to other scientific payloads. The major issue with deploying them on the Moon is their orientation. They must be turned to face the Earth, for obvious reasons. They must not be obscured by nearby mountains or crater rims. Some latitudes on the Moon are difficult to see from the Earth, and it would clearly make no sense to place one on the far side. And a lander that positioned its reflector at an awkward angle would be wasting its payload!

On the Apollo missions, astronauts positioned the reflectors manually. The Lunokhod rovers could turn to place their own reflectors at different angles. Placing a reflector on a future rover is one way to achieve this pointing, if the rover is parked suitably before it shuts down permanently. It could be useful to assume a suitable position before lunar night falls. This will ensure the reflector is ready in case the rover is damaged by the cold, as recently happened to the Yutu rover.

Alternatively, a lander with precision controls could orientate itself in the right way during its descent to the surface, ensuring that its solar panels (as well as the laser reflector) were all pointing the right way. A more extreme method would involve sophisticated robotics. A rover would carry the laser reflector, transport it to a clear location, then place it on the ground, easier said than done.

China is planning two more robot lunar landers after Chang’e-4. These missions will be sample-return spacecraft that will launch rockets into lunar orbit with lunar rocks aboard. Launching spacecraft from the Moon blasts the nearby terrain with rocket exhaust and dust. Thus, these missions are probably not as suitable for carrying laser reflectors.

Other space agencies (especially NASA) are also proposing robot lunar landers of their own for the near future, hopefully within a decade. We need to start planning now. ##
A New Pathway to Mars by Jeff Foust, Monday, June 9, 2014

Periodically, the White House and/or Congress asks NASA to report on its long term goals and their rationale. NASA puts together a report, there is a lot of discussion, and nothing happens. The problem is that NASA can do nothing without the support of the Administration and of Congress and of the American People – none of whom have enough focus or provide enough support to make anything happen.

The latest report, by the Committee on Human Spaceflight of the National Research Council (NRC), “Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration” is available at http://www.nap.edu/catalog.php?record_id=18801 As with all other recent reports, it calls for “international cooperation” and lists human exploration of Mars as the ultimate goal.

Editor: The Committee’s report is interesting, but in our opinion not worth reading, for the simple reason, that like all others, it does not answer the unasked question, “Why?”

Are we going to Mars on a “Kilroy was here” mission so that we can brag that we did it? If we are going just to explore, robots can do that. But if this is to be more than a “Kilroy was here” super feat, a super feather in the human hat, then we must spit it out - “we are going to establish a permanent human presence, permanent human settlement, of a new world, expanding the reach and realm of humanity.” But no Congressional Committee, no Committee of NASA’s own picking, has the gumption to go that far. We are going so we can say

Why is it important to do so? Simple, because if we are going to settle, that changes everything.

- It changes where we will land: we will need to pick a place with a critical list of plusses: access to water, access to key ores, and other assets.
- It changes the list of technologies we will need to master, and their priority.
- It changes what we must bring along – more than that – what we will have pre-landed before the first settlers arrive
- it changes the criteria for crew selection
- it changes the lines of support to which we commit ourselves
- It changes how we look at the Moon, not as a rival goal, but as an essential trading partner with a Mars settlement

This is asking too much of any iteration of Congress, or of any US President, or even of any group of nations. Politics cannot produce anything rational.

We, the people of Earth, will do it anyway, or it will never happen. PK

It’s time for NASA to abandon the Apollo mission model


While the writers of both NASA’s new “Pioneering Space” report and the large new National Research Council (NRC) report on human space exploration (see “A new pathway to Mars” [http://www.thespacereview.com/article/2530/1] (The Space Review, June 9, 2014) are dedicated and well-meaning—the NRC report (extensive, detailed, and thorough)—they seem to have ducked some of the critical decisions and issues that need to be made or resolved for a NASA–led Mars program, or any effective program beyond low Earth orbit (BLEO) to be realized.

NASA itself has the ability to see these problems but it is still not facing them head–on. It is still headed down an antique, dead–end pathway.

[We print the following excerpts in the hope that the reader will read the entire well–thought out article.]

- “In a nutshell, the Apollo Mission model relies on a fully expendable system: a giant expendable rocket, one or two expendable types of crew vehicles, and a focus primarily on science and exploration.”
- “This new ‘pathway’ [to Mars, as described in the report] is the very antithesis of space permanence and Earth–independence.” The report writers use the right buzzwords but propose no matching actions. A quick look through this report reveals a number of such unsupported buzzwords, such as “permanent presence,” “Pioneering,” “Earth Independent,” “sustainability,” and even “infrastructure.” Spudis has continued his analysis with a review of the NRC report. Both articles are well worth reading.
“Relies on a fully expendable system consisting of a giant expendable rocket, one or two expendable types of crew vehicles, and a focus primarily on science and exploration. There would be no base construction at any destination, no unmanned cargo vehicles to provide robust material support, no integration to support multiple goals, and no or little involvement with, or support from, the private sector. This is the essence of the “flags and footprints” type of space mission, justly lauded 40 years ago when it was really necessary, but now a major obstacle to progress.”

“What, then, is the opposite of the Apollo Mission model? It is the concept of a set of continuing missions designed to operate with a set of reusable space vehicles (both for crew and cargo), allowing the creation (and construction) of enduring infrastructure in specific locations in space and at surface destinations beyond low Earth orbit, using local materials, and making each subsequent mission easier, safer, and cheaper.”

“Some experts, including the NRC report writers, think that space infrastructure creates a financial drain on the space exploration budget instead of advancing the program, and that to progress to a new program, old ones such as the station must be abandoned.”

By creating a series of space logistics bases—in LEO, at L1 or L2, and another in low Mars orbit—you create not only a set of refuges for crews in case of problems, but you also greatly increase the reliability of mission success by breaking a trip into smaller segments, each of which can be traversed as a round trip by a single stage (reusable) rocket vehicle. (The only trip segment where this cannot be easily done is from Earth’s surface to LEO. [and Elon Musk is determined to abolish that “can’t” as well] The best example of such a round trip is from L1 or L2 to the lunar surface and back again. Using liquid oxygen (LOX) and liquid hydrogen propellants, a ferry of almost any size can deliver a payload equal to its own dry mass to the lunar surface over and over again. An L1 or L2 base is especially important as a safe place to accumulate vehicles, cargo, and propellant, safe from the high space debris impact levels in LEO. The set of bases creates a logistics pyramid.”

“The existing space station, creates a financial drain on the space exploration budget instead of advancing the program, and that to progress to a new program, old ones such as the station must be abandoned. This dangerous mindset merely continues the thinking of impermanence. Maintaining the station currently costs the US over $2 billion a year. However, if we are to use reusable spacecraft, they must be based, refueled, and maintained at stations or bases of some kind. Logistics capabilities need to be added to the station, or a new LEO logistics base must be built. The further we go away from Earth, the more stations and bases we will need to maintain. Some of these bases can be human–tended and need to be partly self–maintaining.”

“What is also critically needed is research, development, and testing to reduce the amount of money and crew time it takes to operate and maintain habitats and exploration vehicles. Why not use the station we already have for this work? At the moment, funding for such work is not forthcoming due to the same misplaced priorities in Congress and at NASA that have prevented the development of propellant depots. However, in spite of the continuing Congressional disbelief in what amounts to an impending “reusable rocket revolution,” the costs of travel to, and resupply of, space stations and bases of any kind should drop significantly as privately developed reusable boosters come into wider use. This should free up funds for the research work, and will later make building and supporting multiple stations and bases at the same time practical.”

“The asteroid retrieval proposal is a good example of no integration, where there are no plans to use materials from the retrieved asteroid for crew radiation shielding or asteroid mining tests.”

“For real missions to the surface of the Moon or Mars, hundreds to thousands of tons of equipment are needed.”

“With its focus on the budget limits, and the prevailing Apollo–style mindset, a major failing of the NRC report is that it assumes the same high launch and operational costs as for the space station and shuttle, pegging the cost of a manned Mars program between 300 and 600 billion dollars and taking until 2060 to even reach Mars once.”

“The absence of references to reusable vehicles is apparent in both reports. The NASA report refers to reusable systems, and storage of cryogenic propellants, but nowhere does it refer to reusable spacecraft or cryogenic propellant depots, along with the critical requirement to be able to transfer the cryogenic propellants from delivery tankers to the depots and from the depots to the vehicles that need fuel. Without perfecting this technology, we will not be able to use cryogenic propellants in any reusable space vehicle. Logically, the vast bulk of any Moon or Mars base and its equipment should be delivered by separate robot spacecraft, and not as part of a crew vehicle. Virtually no funding is currently available to advance these technologies.”
**International Space Advocacy Organizations Encouraging Student Participation**

NSS currently has chapters in Australia, Canada, Germany, France, Netherlands, Brazil, and India

**NSS’ International Space Development Conference – ISDC**
The “ISDC” is usually held the weekend of the last Monday in May (Memorial Day weekend) in various locations, hosts students from around the world, many of them presenting their entries to NASA’s annual Space Settlement Design Contest. Usually, The Moon Society and SEDS participate in this conference.
[http://isdc.nss.org](http://isdc.nss.org)

The Moon Society has informal relationships with the Calgary Space Workers, Calgary, Alberta, Canada and with the Sociedad Espacial Mexicano, Mexico. The Society has individual members in many countries. The Moon Society’s **Moon Miners’ Manifesto India Quarterly** – the “older sister” to To The Stars International Quarterly, has been going to students and others in India and Elsewhere since August 2008. Older issues are available as free pdf downloads at: [http://www.moonsociety.org/india/mmm-india/](http://www.moonsociety.org/india/mmm-india/)
With the previous issue, TTSIQ#6, that publication replaces M3IQ.

**Students for the Exploration and Development of Space – SEDS**
[http://www.seds.org](http://www.seds.org)
SEDS has had greater success in setting up chapters around the World than any other Space organization.

There are chapters of SEDS around the world: (USA), India, Nigeria, United Kingdom, Philippines, and more; SEDS–Earth is a central node for communication between these worldwide chapters.

**NASA Challenge Invites Students to Design Exploration Systems**
April 3, 2014 RELEASE 14–100 – College and university students had an opportunity to help design systems for future space habitats and exploration systems through NASA’s Exploration Habitat (X–Hab) Academic Innovation Challenge. Applications closed April 30th.

The project challenged students to design and implement new prototype systems that may advance exploration capabilities. To take part in the X–Hab Challenge, student teams submitted their plans for the design, manufacture, assembly and testing of their systems. These plans will be evaluated by the agency's Exploration Augmentation Module (EAM) team, a new agency activity under the Advanced Exploration Systems division of NASA’s Human Exploration and Operations Mission Directorate at the agency's Headquarters in Washington. The AES division pioneers development and demonstration of new technologies for future human missions beyond Earth's orbit.

The EAM consolidated several existing activities to fine–tune its effort to develop prototype systems that augment Orion's habitation and spacewalking capabilities for extended deep space missions. Orion is NASA’s next–generation spacecraft designed to carry astronauts beyond low–Earth orbit, including to an asteroid and Mars. Orion’s 1st uncrewed test flight, is scheduled to launch later this year.

Previous X–Hab Challenge projects included an inflatable loft for crew sleeping quarters, plant growth systems, stowage systems and habitat layout designs.
This year, students could choose projects from a variety of areas: power distribution systems, advanced avionics, inflatable structures, additive manufacturing and food production systems.

The X-Hab Challenge is part of a continuing effort to engage and retain students in science, technology, engineering and mathematics disciplines. The challenge is managed for the EAM project team by the National Space Grant Foundation. Teams selected for the challenge will receive a monetary stipend to assist in producing functional products based on their designs.

For more information on the X-Hab Challenge, visit: [http://go.nasa.gov/x-hab](http://go.nasa.gov/x-hab)

---

**“Ignition!” College Students Light Tiny Fires in Zero–G**


April 11, 2014 – HOUSTON — A slightly dazed group of college students they stepped off a ZERO–G plane to resounding cheers Thursday, April 10th, to celebrate a weightless voyage packed with science experiments, including one test that sparked tiny balls of fire.

Students were measuring how different fuels burn under weightless conditions as part of NASA’s Microgravity University program. The cabin of the ZERO–G plane parked outside of a NASA hangar at Ellington Field looks like a science fair, with Stanford, Arizona State and UCSD banners hanging behind the student experiments strapped down to the padded floor.

Thursday’s flight created brief periods of zero–gravity during 32 parabolas over the Gulf of Mexico. The three students were effusive about awesome the experience was. They took videos during the period of simulated Martian gravity (3/8ths that of Earth), in which they did pushups with remarkable ease and bounded off the cabin floor. They prepared to get pinned to the floor during a period of hypergravity when the plane started pulling up for each parabola.

On Thursday, the first group of UCSD flyers lit tiny droplets of ethanol and kerosene (separately) inside of a triple-contained box. Three other UCSD students ignited butanol and E85 (a combo of ethanol and gasoline), creating small fires shaped like little orbs when free of gravity's pull. ##

---

**1st NASA Human Exploration Rover Challenge – College & High School**


April 7, 2014 — More than 90 high school and college teams from across the planet gather for the 1st NASA Human Exploration Rover Challenge on April 10–12 at the U.S. Space & Rocket Center in Huntsville AL.

The new event, an evolution of the 20-year running Great Moonbuggy Race, will test engineering skills, innovation and problem solving on a rugged ~1,130-meter course simulating diverse terrain challenges of solar system exploration, such as asteroid debris fields, craters, lava tubes, ancient stream beds, erosion ruts and crevasses.

Vehicles are constrained to an unassembled volume of 3.5 cubic meters (a 1.5×1.5×1.5 meter box). The fastest teams to fully assemble and then race their rover through the course will win; prizes are also given for teams that build the lightest vehicles, effectively address safety issues, find creative ways to fix any problems with their rover, and other accomplishments.

The change in nomenclature for this event parallels the metamorphosis of NASA Lunar Science Institute into the Solar System Research Virtual Institute — and the expanding prominence of the entire Solar System as an essential focus of human exploration in the 21st Century. (Image Credit: NASA)
Meeting Apollo 11 Astronaut Buzz Aldrin (front Center) was a big thrill

TTSIQ co-editor Madhu Thangavelu (also originally from India) in center

There is a sizable contingent of students from India attending the International Space Development Conference every year. This bodes well for India’s role in space in the future. Some will find work with ISRO, the Indian Space Research Organization; others with space-related industries.

It is a pleasure to see them and share their interests and enthusiasm.
Purdue students pitch Moon colony plan to NASA


April 17, 2014 – A Purdue University senior design class has a plan to colonize the Moon. The catch? It would cost well above NASA's annual $18 million budget.

PLAN HIGHLIGHTS

1. The proposal calls for three colonies on the Moon.
2. The proposal would cost an estimated $550 billion.
3. It's designed as a stepping stone to future Mars colonization.

A 40-member team of aeronautics and astronautics students outlined its plan to a crowded room, including a few NASA administrators listening in via speakerphone from Houston. “Project Artemis” (Artemis was the Roman Goddess of the Moon) is spelled out in a hefty 1,100 page final report. https://engineering.purdue.edu/AAE/Academics/Courses/aae450/2014/spring/docs/ProjectArtemisReport.pdf

The senior project for the AAE 450 capstone class, it was designed as a possible steppingstone to eventual colonization of Mars. Mars colonization faces several challenges that NASA hasn’t yet addressed. “We can’t solve them ... but we can try to address them and try them on the Moon. “a test bed for Mars.”

No one expects NASA to adopt the proposal in its entirety, considering the price tag. But NASA might look at ideas or portions of the project.

Several years ago, NASA associate administrator William Gerstenmaier, a Purdue alumnus, sat in on the final presentation for the class. Since then, he and other NASA officials have occasionally eavesdropped on the presentations to glean ideas and provide feedback.

SOME PROPOSAL DETAILS

Establishment of three colonies on the Moon — one on the far side, another in a crater and a third in a below-ground lava tube, a feature common in the basaltic maria, the dark areas in the Moon’s “face.”

Proposal timeline:

• Research and development from 2014 to 2022; then four satellites will be launched to establish a communication network between Earth and the future lunar colonies.
• From July 2022 to 2024, the cargo payloads, with everything needed to establish the colonies, would be launched, and robots designed for the mission would build the colonies.
• Colonists would be move to the Moon in May 2024 and would explore until the end of a 4-year mission in September 2028.
• The three lunar colonies would include a living module and a recreation module. Each colony would have four middle-age married couples.

As Longuski sees it, a journey to Mars faces three challenges:

• Radiation levels
• Long-term effects of low gravity on the human body
• Cabin fever

A short-term colonization of the Moon would allow NASA to troubleshoot those issues. Should something go wrong, lunar colonists would face a three-day journey back to Earth, a much shorter — and less expensive — trip compared to that from Mars.

The project goal is to jump-start discussion relevant to the future direction of NASA as some scientists push for further Moon exploration while others urge the pursuit of landing humans on Mars.

“I believe when we go to Mars it will be a one-way (mission) to colonize,” Longuski said. “Whatever country ends up doing that ... whatever their culture value, their language, their beliefs are, will be represented by people on Mars. One question I’d like to ask is: Do we want to be a part of that?”

The mission’s overall success rate is 80 percent, The odds of the colonists not returning safely to Earth is about 17%. “This is a little bit high. But we have to consider we’ve never done this before. This is eight times longer than our astronauts have ever stayed in space.Cabin fever is a real concern, one that might be mitigated by using married couples. “If there is a fight, there is a couch in the basement!”

[EDITOR: Thanks guys! See the editor's article above, on “Avoiding Cabin Fever.”]
Students Design Radiation Shield for NASA's Orion Spacecraft

April 25, 2014 – NASA is developing a new spacecraft to take crews into deep space, and high-school students will have an important role in designing it.

The Orion Space Capsule, is designed to take a new generation of astronauts to the Moon, nearby asteroids and Mars. In December 2014, the spacecraft is scheduled to embark on an unmanned, 4-hour test mission, traveling to an altitude of 5,793 km (3,600 mi). To do so the capsule will have to pass through the Van Allen Radiation Belt, a loop of charged particles trapped in the Earth's magnetic field. Without protection, the Van Allen radiation could damage some of the spacecraft's sensitive instruments.

To learn more about how to protect Orion, high-school student teams have been competing in the Exploration Design Challenge — sponsored by Lockheed Martin, NASA and the National Institute of Aerospace — to design a shield to guard Orion's radiation detector.

Five student teams have been working with an assigned mentor to refine their designs and upload them into OLTARIS (the On-Line Tool for the Assessment of Radiation in Space) for virtual testing. The Exploration Design Challenge "was launched on March 11, 2013, to give students from kindergarten through 12th grade an opportunity to play a unique role in the future of human spaceflight. "The challenge encourages students in the U.S. and abroad to think and act like scientists and engineers to overcome one of the major hurdles for deep-space long-duration exploration: protecting astronauts and hardware from the dangers of space radiation. So far, a total of 125,000 students from 81 countries around the world have participated in the challenge.

The winning design was announced on April 25, and will fly on Orion's first flight later this year.

Student Team Wants to Launch Time Capsule to Mars

April 28, 2014 – A group of students wants to send a time capsule filled with images and sounds from life on Earth to Mars. The project, called Time Capsule to Mars, aims to develop and load three small, identical spacecraft with photos, messages, audio and video provided by people from around the world. By launching the small probes on a mission to Mars with messages aboard, project creators hope to leave mementos of life on Earth for future humans traveling to the Red Planet.

"Why is Mars a good destination?" Emily Briere, an undergraduate at Duke University and one of the founders of Time Capsule to Mars, asked during the Humans 2 Mars Summit this week.

"For our generation, it's so bold and yet achievable. It's just within our grasp as students, as something we can see ourselves having a measurable impact on, and see ourselves extending and doing the research on the technology and actually pursuing a landing on Mars."
A group of students are developing a mission that would land three spacecraft (one pictured above) carrying images of Earth to the surface of Mars.

“Time Capsule to Mars” will be a crowd-funded project. People around the world will be able to send in their messages for as little as 99 cents. The more space a message takes up, the more a person will need to pay to send it to Mars. Videos will cost more to send than photos or text. The collected messages will be copied onto the small satellites before launch.

The three spacecraft might be identical in design, but the messages contained in each will be diverse, each probe carrying different data. Users can buy data on all three to up chances of arrival.

"When we get to Mars, we're going to deploy the payloads. We’re not trying to preserve the three spacecraft themselves. They will disintegrate in the atmosphere. The payloads are designed to aerobrake and self-land on the surface of Mars without damaging the data. Then, your pictures, videos, – ‘you’ – will remain on Mars until future colonists get there to discover you."

At the moment, the Time Capsule to Mars team doesn't have an official timeline; however, they're hoping to be the first private team to successfully land something on Mars. The total cost of the mission could be about $24 million.

---

**NASA Announces 2014 International Space Apps Challenge Global Award Winners**


May 16, 2014 – RELEASE 14–132 – NASA mission priorities were explored by five winners of the 2014 International Space Apps Challenge, a worldwide "hackathon" to spark innovation with direct application to future space missions and improve life on Earth. NASA judges have selected five challenge winners, and the global social media community selected a People's Choice fan favorite.

The competition took place at 95 locations around the world April 11–12. More than 8,000 participants developed software, hardware, data visualizations, and mobile or Web applications for the challenge. This year, nearly 40 challenges represented NASA priorities in five themes:

- **Earth Watch**
- **Technology in Space**
- **Human Spaceflight**
- **Robotics**
- **Asteroids**

The challenge categories and winners are:

- **Alert/Alert challenge: SkyWatch: Best Use of Data**, created at Space Apps Toronto. The SkyWatch app is a visual representation of data collected from observatories around the world in near real time. The app provides telescope coordinates of celestial events, and plots the location through Google Sky. Users can subscribe or filter sky alerts, and share them through social media.

- **PhoneSat challenge: Android Base Station: Best Use of Hardware**, created at Space Apps London to transform a smart phone into wifi hotspot by connecting to satellites using a 3-D printed receiver. This automated, ultra-portable, satellite tracking station can log changes in micro-satellites in orbit. PhoneSats are another way NASA is innovating new technologies to support the missions of tomorrow.

- **Space Wearables challenge: Aurora Wearables: Best Mission Concept**, created at Space Apps Exeter as a collaboration between artists, fashion designers, technologists, and software developers: internet-connected spacesuit for astronauts to wear on the International Space Station and beyond.

- **Earth as Art challenge: Yorbit, Most Inspiring**, created at Space Apps Kansas City as a way to search, personalize, and share the stunning photographs captured by NASA satellites orbiting high above Earth. Searching by date and image, users can choose images from unique maps and write message on the image to share using social media or email.

- **My Sky Color challenge: SkySnapper** – created at Space Apps London to measure air quality by snapping photos of the sky. Crowd-sourced sky images are mapped to assess air pollution by sky color to spot polluted areas and monitor progress over time.
Social media users around the world joined the contest as judges, voting for their favorite projects. People's Choice Award winner **Space Helmet**, created by Space Apps Valencia, received the highest score based on a formula that took into account the number of tweets, unique users and timeline deliveries.

All award finalists were nominated at the local level from among the local winners. Submissions for global judging were required to create a 30-second video to describe the project solution. More about the International Space Apps Challenge and recent winners, [http://spaceappschallenge.org](http://spaceappschallenge.org)

---

**NASA Selects Five Projects for 2015 X–Hab Academic Innovation Challenge**

June 11, 2014 RELEASE 14–162

NASA and the National Space Grant Foundation have selected five universities to design systems, concepts and technologies to enhance capabilities for deep space missions for the 2015 Exploration Habitat (X–Hab) Academic Innovation Challenge.

The selections are the first milestone in a yearlong design and development effort for these five projects. Throughout the 2014–2015 academic year, the teams must meet a series of milestones to "**design, manufacture, assemble and test**" their systems and concepts in close cooperation with members of the NASA Exploration Augmentation Module (EAM) concept team.

EAM is a new agencywide technology development concept managed by the Advanced Exploration Systems Division in NASA's Human Exploration and Operations Mission Directorate. The EAM will combine several capabilities into a prototype system to **augment Orion's habitation and extra–vehicular activity capabilities for extended deep space missions.**

This design challenge requires undergraduate students to explore NASA's work on **development of deep space habitats** while also helping the agency gather new ideas to complement its current research and development.

The five X–Hab Academic Innovation Challenge 2015 teams and projects are:

- University of Wisconsin, Milwaukee: **Design of a Carbon–fiber/Fused Deposition Modeling Spacecraft Structural Fabrication System**
- University of South Alabama: **Development of a Volumetric Adsorption System for CO2 and H2O Multicomponent Isotherm Measurements**
- University of Vermont: **Design of a "Smart–Structure" Deployable Airlock**
- Oklahoma State University: **Deployable Greenhouse for food production on long–duration exploration missions**
- University of Colorado at Boulder: **Deployable Greenhouse for Food Production**

This challenge also contributes to the agency’s efforts to train and develop a highly skilled scientific, engineering and technical workforce for the future. The National Space Grant Foundation will administer the grants to the universities for NASA to fund design, development and evaluation of the systems by members of the NASA teams during the 2014–2015 academic year.

For further information about previous challenges and current challenge requirements, visit: [http://go.nasa.gov/x–hab](http://go.nasa.gov/x–hab)

---

**'Losing the Dark' Video Illuminates the Threat of Light Pollution**

Earth Day: April 22, 2014 – A short video seeks to stem the rising tide of light pollution, which is robbing many people on Earth of the dark night skies that showcase the universe around us.

Light pollution doesn't just make it more difficult for professional and backyard astronomers to observe the heavens, according to the 6.5–minute film, called “Losing the Dark” The loss of darkness also disrupts wildlife, wastes resources and adversely impacts human health.

"Exposure to light at night disrupts the circadian rhythms that regulate our sleep cycles," narrator Carolyn Collins Petersen says in the video, created by the International Dark Sky Association in collaboration with Loch Ness Productions as a public service announcement. "People working at night under bright lights or living in light–polluted cities face a higher risk of developing diseases such as breast and prostrate cancer."

We are not powerless in the face of ever-encroaching light pollution, the video asserts. Three simple actions can help darken our skies and bring our energy bills down.

1. We can replace light fixtures that send light up to the sky with ones that direct light down — exactly where we want it. They’re called fully shielded fixtures.
2. We can also illuminate only the places that need it.
3. We can just turn off unnecessary lights.

"Losing the Dark" can be downloaded free at the International Dark-Sky Association website above. International Dark Sky Week is an annual celebration, which began in 2003 and runs from April 20–26 this year, aims to foster a better appreciation of the night sky, raise awareness about the problem of light pollution and inspire people to take action, event organizers said.

There are many events taking place around the world during International Dark Sky Week. Check http://nightsky.jpl.nasa.gov/event-list.cfm to see if there is an event happening near you.

### How To Become A NASA Astronaut


Astronauts do activities related to human space exploration. The most visible parts of their jobs take place while working in orbit, but most of their careers will be spent on the ground training and supporting other missions.

Years of education and experience are needed to meet the basic qualifications. Many aren’t accepted on the first try. That requires them to learn more to be better prepared for a second try. Only a small percentage of applicants become candidates—a hard job to get. Each space agency has its own selection process.

**Non–U.S. citizens in the following geographical areas** should consult one of these agencies for more information on becoming an astronaut:

- European Space Agency
- Japanese Aerospace Exploration Agency
- Canadian Space Agency
- Russian Federal Space Agency
- China National Space Administration

The right stuff for military and civilian applicants

The first step is getting relevant experience in school. Military application procedures vary depending on the branch of the U.S. armed forces you are working for, since you apply through your respective branch. Civilians apply to NASA directly.

NASA wants its astronauts to have at least a **bachelor's degree in engineering, biological science, physical science or mathematics**. Many have a **master's degree or even a Ph.D.** in their field. See: [http://www.nasa.gov/centers/johnson/pdf/606877main_FS-2011-11-057-JSC-astro_trng.pdf](http://www.nasa.gov/centers/johnson/pdf/606877main_FS-2011-11-057-JSC-astro_trng.pdf)

### More than schooling: experience and health

NASA wants at least three years of "related, progressively responsible, professional experience" or (in a nod to military candidates) at least 1,000 hours of "pilot-in-command time in jet aircraft." Advanced degrees are considered equivalent to this experience, however, with a master’s equaling one year of experience and a doctorate three years of experience. Teachers must have a technical bachelor's degree but can qualify through the act of teaching — even for elementary school children.

NASA astronaut candidates must also pass a demanding physical. Among the requirements:

- 20/20 vision (either naturally or with corrective lenses)
- Blood pressure not more than 140/90 in a sitting position
- Height of 62–75 inches (157–190 cm)

In general, you must be in extremely good shape to be an astronaut as it’s expensive to make an emergency return to Earth in case of medical emergency in orbit.

**Interviews:** NASA tries to determine if a candidate is physically and psychologically able to work as an astronaut. Flexibility, group work skills and a love of learning are personality traits NASA looks for.

### Astronaut candidacy and path to flight

Being selected does not make you an astronaut. There are two years of basic training ahead as an "astronaut candidate." Candidates receive basic classroom learning about the Space Station and spaceflight generally. They must become qualified scuba divers, do military water survival training, undergo swimming tests, are exposed to high and low atmospheric pressures, do flights in the "vomit comet" and get media and Russian language training, among other things. 1:
Many graduated astronauts are not assigned to a flight for years. They will back up other astronauts in orbit through serving as a "CapCom" in Mission Control, doing simulated spacewalks in NASA's Neutral Buoyancy Laboratory and picking up more skills they will need for their time in orbit. They spend time with international partners that have training facilities (such as Canada, to learn how to operate the station's robotic arm.

Astronauts must maintain flight proficiency on T-38 aircraft, flying X number of hours per month. Once selected for a flight, one’s mission training takes another couple of years. Reading textbooks and classroom training, then simulation after simulation to learn the stuff for real. Their training takes place all over the world, both individually and with their crew mates. Several full-scale mockups and trainers are also used for onboard systems orientation and habitability training.

A typical spaceflight these days for a NASA astronaut lasts six months on the International Space Station, but some astronauts are now being assigned to year–long flights to learn more about the human body. Science will take up most of an astronaut’s time in orbit. ##

List of Recent Feature Articles and Essays in Our Sister Publications

Ad Astra [Latin (ancient Roman): “To The Stars”]
Sent to all National Space Society Members as a primary membership benefit
(with choice of print hardcopy or downloadable pdf file)

SUMMER 2014 issue
12 Life in Mission Control – Paul Brower
18 Five Technologies for the Future – Clifford R. McMurray
22 Marking Milestones on the way to the Moon: The Google Lunar X–Prize – Andrew Barton
26 Reviewing Space Solar Power Policy – Paul Werbos
30 Sea Legislative Blitz: A First Timer’s Experience – Kimberly A. Terrell
32 The Roll of NSS at the United Nations – Dave Dunlop
34 NSS Board of Directors Candidate Statements

Members also receive NSS online NSS' formatted email newsletter, NSS Downlink

www.MMM-MoonMinersManifesto.com

MAY 2014 – MMM #275
2 In Focus: What’s ahead for Moon Miners’ Manifesto – Peter Kokh
3 Detecting “Adolescent” Civilizations around Other Suns – Peter Kokh
4 Where to start the first Outposts on Mars – a suggestion – Peter Kokh
7 Settlements “Standing Proud” on the Monochromatic Moon and Mars – Peter Kokh

JUNE 2014 – MMM #276
2 In Focus: The Lessons of Grytviken – Peter Kokh
3 Avoiding “Cabin Fever” on the Moon and Mars – Peter Kokh

MMM is not published in July, or in January

Non–time sensitive articles from past issues are available online in pdf format in two sets of Collections
MMM Classics issues collect articles in collections by publication year with 2–3 year lag
http://www.moonsociety.org/publications/mmm_classics/

MMM Themes issues collect articles according to various “themes”
http://www.moonsociety.org/publications/mmm_themes/
Discovering our own Solar System in ever greater Depth

The past three months have been especially exciting for those of us interested in all aspects of Space. Developments in “Near Earth Space,” the Moon, Mars, Mercury, Venus, asteroids, comets, Ganymede (Jupiter), Titan, Enceladus, and Iapetus (Saturn), Pluto and beyond continue to deepen, refine, and reshape our knowledge about our own Solar System.

Meanwhile we are learning how to mine ever more information from our several space telescopes and the growing armada of ever-more powerful Earth-based telescopes to learn things we had never dared believe would someday be within our grasp. And what we learn about other planets, in our own system or around distant stars, puts our own home system and Earth itself in an ever deeper ever more complete context.

We have begun to find out things that previously had been thought to be forever beyond our ability to discover. It is an exciting time to be alive, for those of us with unquenchable curiosity. But our born-again intellectual journey is just beginning.

To our thinking, the term “Earth-like-planet” is used far too freely. It is not enough to be a rocky planet in contrast to Jupiter- or Neptune-sized “gas giants.” “Earth-like” should be reserved for worlds on which the surface is part ocean, part continent - that is, “Hydro-Tectonic” worlds. See our article, linked to by the following image::

http://www.moonsociety.org/images/changing/m_class_planet.gif

But at the same time, we now realize that there are other types of life-hosting worlds: such as the Europas, and the Titans. Such life-siring worlds can apparently thrive even with out “parent” suns.

It is a great time to be alive, and a great time to report on the ever accelerating pace of discovery!

Discovery from a distance versus Going out there, spreading mankind.

While government funds have been supportive of astronomy and unmanned probes, there has been very little support about going “out there” in person. It “costs too much” and governments whose decision makers are motivated by other priorities give only lip service to manned expeditions “sometime” in an ever-receding future.

Space Societies need to stop pinning their hopes on governments, and try to brainstorm how “we - the people” are going to do it anyway. Industries will benefit from developing technologies that will be appropriate on other worlds, because they will have applications that are profitable here as well.

Two examples: the concept of glass fiber-glass matrix composites pushed then abandoned by the Space Studies Institute, and a parallel concept of basalt fiber-basalt matrix composites being developed for terrestrial uses in India. “Spin-up” not “spin-off. SSI did nothing to interest entrepreneurs from pre-developing technologies most useful on the Moon for their profitable applications here on Earth. Read our 1987 article (yes, 27 years ago):


Fortunately, there are entrepreneurs out there who see the possibilities. One of those is Elon Musk, who is busy developing one new technology after another, such as reusable first stage rockets. We must not look to our Congresses and Parliaments, but to commercial opportunities.

Exploiting the Earth-Moon System “high ground”

Business, had it been on the ball, could already have established a foothold on the Moon to exploit the Moon’s high ground: it takes 1/23rd as much fuel to deliver something needed in GeoSynchronous Orbit (GEO) from the much greater distance of the Moon than from the much closer distance of Earth’s surface. It is not true that there is no “up” or “down” in space. There is an enormous difference between “down a gravity well” and “up a gravity well.” GEO already accounts for over $300 billion of economic activity, enough to make GEO, were it a nation, to join the “G-20” the twenty largest national economies on Earth. That by treaty, there are only 180 slots, 2 degrees apart, puts a limit on economic growth in GEO, but building large platforms at each location to host myriads of satellites each, along with solar power generation, would allow GEO’s net product to grow beyond any current expectations. Earth’s economy already has a diameter seven times that of Earth itself, from one side of GEO to the other.

If our Congresses and Parliaments will not front the money, perhaps that is best, because such funds come with strings. We have to find ways of funding such “spin-up” industries on our own. Had we been doing this for the past 25-30 years, there would be self-supporting settlements on the Moon today, and on Mars tomorrow - instead of an ever slipping and growing number of years in the future by NASA’s way of raising money.

It is high time for “Grass Roots” “Space Societies” to look elsewhere than to governments. Political action is a trap. Every seeming victory is an illusion. There is hope. In addition the “don’t tell me what is and is not possible” people like Elon Musk, there are enterprising people who just happen to see possibilities that can make money here on Earth, without considering that these possibilities can open doors beyond.

And we are finding new ways to raise “seed money”: crowdfunding and Bit Coins.

There is hope, and it does not lie in “political action.”

---

Peter Kokh, Editor
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.moonsociety.org/publications/mmm_classics/

MMM Classic Theme Issues: introduced a new series to collect the same material as in the Classics, but this time organized by theme. The first MMM Classic Theme issue gathers all the Mars theme articles from years 1–10 in one pdf file. A second pdf file collects all the Mars Theme issues from year 11–20. The 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.

All of these resources are available online or as free access downloads to readers. But TTSIQ does need your help!

To The Stars International Quarterly Advisors, Liaisons, Contributors, Reporters, Illustrators

If this publication is to help spread the word about Space worldwide, among the public at large, especially among the students and younger people, it must become a truly International publication. We need people from many fields to join our team.

If you think 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 [This email address goes to 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 India, and in the education of young people on whom the future of the world rests.

Guidelines for Submissions  TTSIQ is intended for wide public distribution to encourage support for space research and exploration and development.TTSIQ is not a scholarly review or a technical journal for professional distribution. Submissions should be short, no more than a few thousand words. Longer pieces may be serialized editorials and commentary, reports on actual developments and proposals, glimpses of life on the future space frontier, etc. Articles about launch vehicles, 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 a new issue if 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/  and  http://www.moonsociety.org/international/ttsiq/
To The Stars International Quarterly #8: July 2014 Index

2 Co-sponsoring Organizations

**NEWS SECTION pp. 3–106**

- 3–24 Earth Orbit and Mission to Planet Earth
- 25–38 Cislunar Space and the Moon
- 39–40 Space Tourism
- 41–62 Mars
- 63–70 Asteroids & Comets
- 71–87 Other Planets & their moons
- 88–106 Starbound

**ARTICLES & EDITORIALS pp.108–128**

- 108 Early Supporters of Manned Mars Missions Addressed the Risks Involved: – Peter Kokh
- Wanted Split personality types for Mars Expeditions – Peter Kokh
- 110 Mars Gravity en route to Mars – Peter Kokh
- 112 Artificial Gravity enroute to Mars and back strongly advised – Peter Kokh
- 113 NASA’s Timid record on Demonstration of Artificial Gravity in Space – Peter Kokh
- 114 Avoiding “Cabin Fever” on Moon and Mars – Peter Kokh
- 120 The Case of Cislunar Cubesats – Dave Dunlop & AL Anzaldua
- 123 Lunar CubeSat Projects, Mission Proposals, and Technologies – Dave Dunlop
- 125 After Russia Leaves the International Space Station – Dave Dunlop
- 126 Online Op-Ed articles from other Writers worth reading

**STUDENTS & TEACHERS pp. 129–136**

- 137 Recent Feature Articles in Our Sister Publications: Ad Astra; Moon Miners’ Manifesto
- 138 About this issue: Peter Kokh

Reader suggestions for improvements in TTSIQ are welcome. Email kokhmmm@aol.com

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

---

The Stars International Quarterly #8

Engage! And Enjoy!